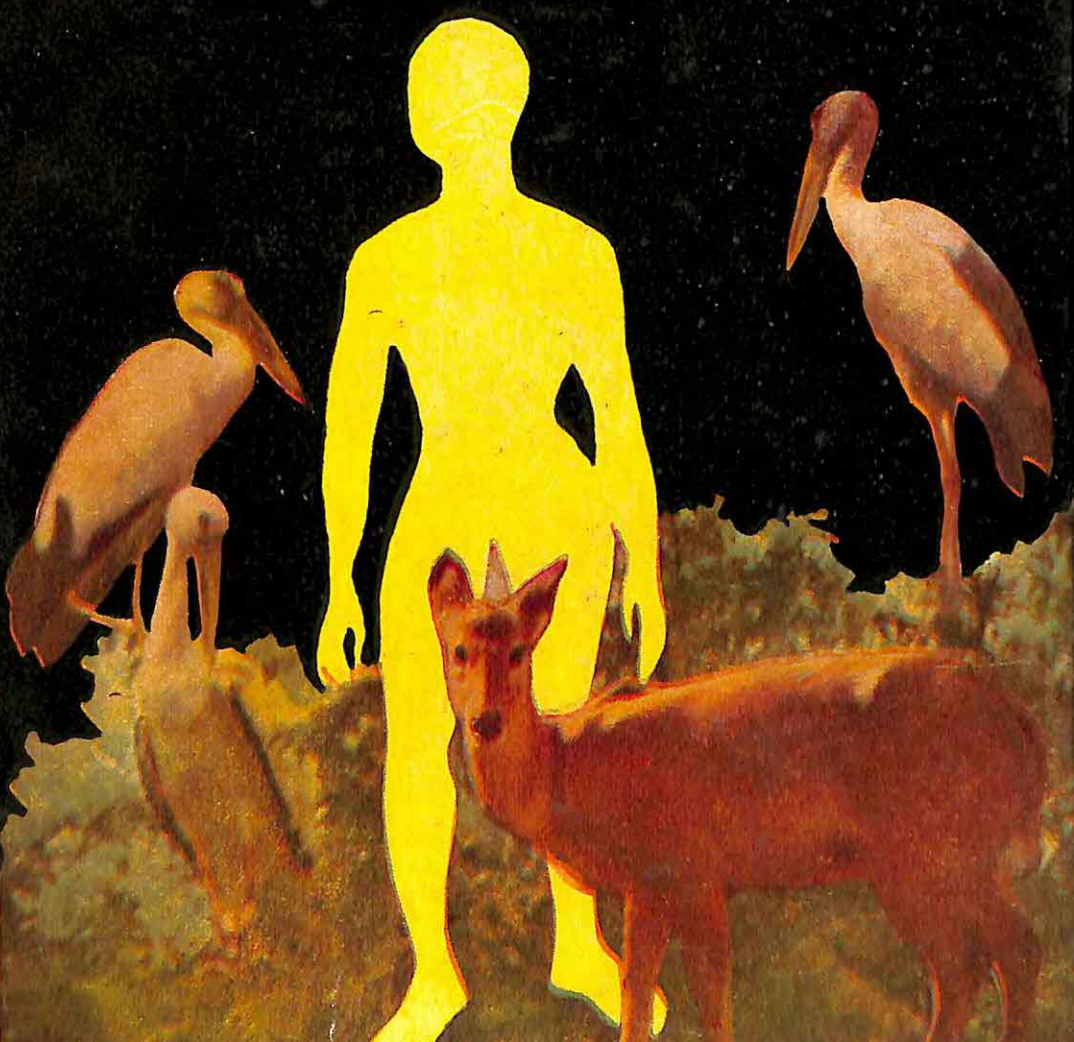
Dr. Kalyan Chakravarty

Man Plant & Animal INTERACTION



ABOUT THE BOOK

In this book a triangular relationship amongst men, plants and animals have been established and bridged a long-felt vital gap in the information flow in an ecological setting. Its unique feature is the narrative description of the evolution of Indian forests, their diversity through the ages and their general impact on social ecology. The ecological imperatives of men and nature have been lucidly depicted. Bio-ecological parameters have been described in a style of author's own experience. Economic prospects of different ecological settings have also been highlighted.

This book will be of great use not only to the scientists, research workers and students in the field of environment and ecology but will also cater to the needs of conscientious general public taking interest in nature and environment. And this is the beginning of the burning subject.

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Dedicated to
My Late Mother

PREFACE

Living organisms on the earth are mutually interdependent for their sustenance, growth and development. This is a fact not often realised, and if realised, such realisation is not seemingly brought to bear upon the actions of man. The man acts in self-interest in blissful oblivion that such mutually beneficial interdependence which is called symbiotic relationship, should be preserved to foster a balance in nature.

It is important to know how and to what extent various kinds of interdependent relationships keep balance in nature and how this balance is likely to be disturbed by continuous and deliberate actions of man. Plants and animals share physical locations or regions conducive to their mutual sustenance and growth as part of their symbiotic relationship. They adapt, adjust and modify themselves to certain conditions of a locale. They face the threat of extinction if the mix of conditions were somehow changed, climate, sources of food, etc. Hence it is possible to indicate the spatial distribution and habitat of plants and animals of varying types in certain regions or areas. Such spatial distribution can also be observed among human beings in relationship with plant and animals. So, the people, plant and animals are caught in an unending chain of relationship, each influencing the other and being influenced by it to foster a balance in nature.

This ecological study of separately distinct three parts of West Bengal, originally carried out for doctoral dissertation in anthropology from Sambalpur University, assessed the overwhelming extent of dynamic relationship between the man on the one hand and plant and animals on the other, and the importance of restoring balance in nature through deliberate policy actions.

The study was unique of its kind since not much literature was available in this field. There was therefore little to draw on the earlier experiences. The field work was done over a long period of time while serving important assignments under the Forest Directorate of the Government of West Bengal. During my tenure as Field Director, Sundarbans' Tiger Reserve, I had the rare opportunity of making a study not only of the forest resources but also of forest type and faunal diversity of the

Sundarbans' littoral and swamp forests. Forestry personnel helped me in the study in many ways.

Some individuals extended valuable cooperation at different stages of the study. Mention may be made of Shri A. B. Chaudhary, N. K. Evdow, G. C. De, S. N. Pal and S. K. Biswas. I gratefully acknowledge their services.

I am indebted to Dr. S. N. Ratha, Professor and Head of the Department of Anthropology and Sociology, Sambalpur University and to Dr. P. K. Bhowmik, Professor of Anthropology, University of Calcutta for their guidance.

I owe a debt of gratitude to Shri Barindra Mitra of Naya Prokash for having taken great pains to publish the results of my research in the form of a book for consumption of general readers.

Calcutta
November 15, 1990

Kalyan Chakrabarti

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Introduction

A mutually interdependent relationship binds man, plant and animals together as essential parts of environment. But this relationship is hardly realised by man who has been through the ages the principal agent of change, trying to create a new order in which he is the master. Conditions of imbalance in nature have been caused by man's deeds and since nature is not used to bear with a state of imbalance for long, it must seek to restore its balance even at the cost of causing large-scale human misery. It is true that man has interfered with nature without being fully aware of the possible negative consequences. Now that such negative consequences are loud and clear it is important to know what constitutes the balance in environment, whether maintained through natural process or through man's intervention.

Man, acquisitive and extractive by nature, has multiplied in the wake of conspicuous decline in mortality and so extended the range of his needs that he was tempted to extract more from the earth than what it would gracefully yield. He made bad use of land, water, forest and mountains and exported the ecosystem for the benefit of those who did not live there. In 1620 catalogue of living species included 4226 mammals of which 46 are already extinct and 152 are endangered. Man's so-called love for sport, his greed for magical powers, for ivory, for bones, oil, meat, for fur and feathers, for horns and antlers has endangered the elephant, the rhino, the whale, the tiger and the giant panda, among others . The auk, the dodo, the moa, and the carrier pigeon are among the many species of extinct birds. All the 146 species of tropical fish previously catalogued in Malaysian river are extinct today.

Deforestation of tropical rain forests, for instance, has destroyed not only unique and singular plant life, but also the habitat of hundreds of species of birds, insects, reptiles and mammals. Unplanned industrial growth has played havoc with ecosystems in many places in the world. Dams and hydroelectric projects

in the Himalayas have resulted in deforestation and erosion in the hills, and floods and famines in the plains. Ecological degradation has set in across the entire Himalayan range.

Pollution is yet another face of ecological degradation caused by reckless growth of industries. It not only destroys the complex interrelationship between lower and higher life forms, but also causes future disasters. For pollution is the result of industrial effluents of toxic waste, ever increasing amount of pesticides in food and nitrates going into water. Pollution is caused by the release of increasing amount of chlorofluorocarbons into the atmosphere creating holes in the ozone layer. Pollution from fossil fuel, power stations and exhaust gases from cars heats up the earth's atmosphere and causes what is known as greenhouse effect.

There is an all-round ecological degradation and loss of balance. A healthy environment cannot be made from widespread negative consequences which have stated causing immense trouble to mankind. The study of ecology has assumed immediate importance because we must know, what constitutes the ecological balance and how interdependent is the relationship amongst man plant and animal.

Forests constitute a significant feature of the land surface. In form and content they vary widely from one region to another and stand in marked contrast to meadows and pastures. The scenic beauty of forests keeps on changing seasonally. The kaleidoscopic change of the mosaic pattern in spring is quite different from the sombre darkness of the winter or the pollard trees of the summer. The shedding of leaves of some deciduous trees change the forest ground into a golden-yellow hue, while the sprouting of new foliage at the nodal points of trees or burgeoning buds during the spring present a picturesque look. Such autumnal and vernal tinges are a pleasing sight against the generally green or straw-coloured background. Trees being stoically static creatures cannot withstand the adverse effects of the environmental onslaughts to which they are open. For their survival they resort to such methods as leaflessness in summer for minimising transpiration, developing thorns for warding off browsers, oozing poisonous sap, etc., i.e., their variability is the result of adaptation to different adverse situations on the earth's surface. The primitive hunting-gathering nomadic man

had to depend mostly on forest produce for food and shelter. Slowly the economy of these people changed. The food-gatherers turned into settled food-producers. They assigned special importance to some specific types of trees and plants which they found useful. Lands were brought under cultivation after they were cleared of forests. A new relationship began between the animal world and plant world. The relationship was of inter-dependence. It was developed and maintained through natural process.

Barks, leaves, flowers, tubers and roots proved important commodities for human sustenance and became an integral part of civilization. An important role was played by forests in the lives of the people. In Indian tradition plants, trees and forests are treated with esteem. The trees assumed an exalted position in different rites and ceremonies. The Vedas, the Upanishads and the Aranyakas were composed in sylvan surroundings of the forests and the glory of the Creator was sung. Holy forests, such as, Naimisharanya, Dandakaranya and Panchavati were treated as part of nature and were worshipped.

Thus, plants, animals and men are mutually dependent on each other to maintain ecological balance through the natural process depletion and repletion of their stock. All of them together constitute a system. Destruction of one part of this system can lead to serious repercussions on the human life and cause imbalances in nature. This was apparently known to people. This is evident from religious taboos and restrictions of indiscriminate felling of trees and killing of animals. The forest conservation of programmes and various other allied activities seem to suggest that policy-makers were not unaware of the importance of interdependence.

II

Emphasis on forest ecology is rather recent in India. Mohan (1933), Suri (1933), Gorrie (1933), Glover (1930), Toovor (1917) made valuable contributions to the understanding of ecology for the North and North-West Himalayan Forests. Taylor, Mahendry, Mehta and Hoon (1936), Puri (1950), Puri and Gupta (1951), Mohan and Puri (1954), made indepth studies of the relationships of forest vegetation with geology, soil and other factors of

the habitat. Champion's monographs on shorea robusta (1933) and forest types (1938) are notable additions to knowledge on forest ecology. For the Eastern and Central India, Bor (1938 to 1942), Mooney (1933-38), Heweton (1941), Kulkarni (1951), Waheed Khan (1953), Tiwary (1941), Puri (1954-55), Misra and Joshi (1952), Bhatia (1954) and others have also made some useful contributions on the subject.

This study was undertaken over a period of 18 years in three typical forest-fringed villages in three different ecosystems of West Bengal, namely, Pampoobasti in Jalpaiguri district, Talpukuria in Midnapore district and Gosaba in 24 Parganas district. A socioeconomic study was conducted in all the three villages to determine the extent of their dependence on forests. The study was conducted while I served under the Forest Directorate of the Government of West Bengal. This provided me an opportunity, not otherwise available, of taking a close look at the triangular relationship among plants, animals and men.

While serving as Field Director, Sunderbans Tiger Reserve, I had a unique opportunity of studying closely not only forest resources but also types of faunal diversity of Sunderbans littoral and swamp forests, including honey collection and fish resources of the tract. Facilities were provided to enumerators to observe and record the floral, faunal and human interactions in the littoral forests of Sunderbans.

The forests of West Bengal are classified into four distinct types, namely, hill, plain, littoral and mangrove and laterite forests. Linear transect lines were laid out in different parts of the forests to study classification of vegetation and animal-vegetation dynamics of different forest zones of West Bengal.

The Sunderbans swamp forests were classified for this purpose into three different zones as follows : (A) situated above tide level, (B) frequently inundated by tidal waves, (C) situated below tide level.

Laterite forests were categorised into two divisions : Natural forest and Artificial forest. Each category is subdivided into several plots measuring 0.4 hectare each and 20 plots of each of the above categories were selected at random out of the total number of plots. The number of genera, species and individuals were counted to find out the generic and specific diversities of

vegetation as also animal complex of each zone. The methodology for determining the relative abundance of plant-animal dynamics was applied to calculate the generic and specific diversity. For the purpose of determining the specific diversity, samples were taken by units from a population arranged in a log series of distribution. Diversity is known to be a yardstick to measure the intensity of variety in animal or plant community, apart from the absolute abundance of species or individuals. The concept of diversity can be used to measure the relationship between different kinds of fauna and flora and that low specific diversity is characteristic of a population in an environment where physical conditions are severe or specialised. In a physical environment the chief determining factor of the balance is biological competition and the resultant diversity is high in a healthy ecosystem.

Any plant or animal population in wild state consists basically of a very large number of 'individuals'. In some cases, particularly in the plant world, this simple unit is difficult to define. The total number of living individuals at any given time is incalculable. The 'individuals' in different species and the number of species in different genera vary within wide range.

It is known that either a very small or very large number of a species can bring disaster. A small number makes it difficult to find mates and becomes rare. Such animals are usually very localised. A large number may cause increase or concentration of enemies or of epidemic diseases. They may face the threat of starvation in the event of a sharp fall in the availability of food, either seasonally or over long period.

The number of individuals within a species and the number of species within a genus change from one season to another and the extent of these changes is largely determined by the interaction of birthrate, the length of life and the death rate before maturity. In the midst of such a complex situation the individuals of each species have to struggle for survival against the physical properties of their immediate environment like weather, changing seasons, soil and water conditions, and in competition with all other species of living creatures. The success or failure in their struggle determines the increase or decrease of individuals in the species. Each one of the species temporarily maintains an uneasy balance of numbers. So, the position of one particular species

in relation to others is always changing which makes the subject as one of perennial interest.

It is all the more important therefore to find out whether, as the time goes on, the fundamental pattern changes or if the species move in their relative abundance with a more or less stable pattern. This is how the approach to the 'balance of nature' from the point of view of quantitative synecology is made. As the number of individuals differs greatly from species to species, so also the number of species differs from one genus to another on a much smaller scale.

The diversity in animal or plant world, a measureable character, has opened up new vistas of growth and development in the concept of ecology and has laid bare the secrets of living forests, competitions among the living beings in the forests, the probability of extinction of any of these.

III

The concept of 'diversity' can be applied to measure the relationships between different kinds of fauna or flora. That low specific diversity is characteristic of a population in an environment where the physical conditions are severe or specialised follows from application of this concept. In easier physical environment, such as, in the tropics or subtropics, what determines balance is biological competition, with the resultant diversity being high. In this connection, Gotts Chalk and Jones (1955 : 136) say :

'A plot that loses soil at the rate of 100 tons an acre under fallow or up-and-down hill cultivation might lose only 10 tons if it is planted to small grains, 2 tons if it is in good pasture, and less than 1 ton if it is in good forest cover.'

Having examined how rainfall and soil erosion affect human life and vice versa, Ben Osborn writes (1955 : 127) :

'The total energy of raindrops has been calculated as being equal to roughly 100 horsepower at 2 inches an hour. The latter is a sufficient force to lift the 7-inch top soil layer to a height of 3 feet, 86 times during an hour's rain, equivalent to 518 million foot-pounds of work.'

In his doctoral thesis entitled 'Forestry in the Rural Economy of India with particular reference to Agriculture', Parasnis (1976 : 15) says :

'For centuries, the forests have formed an important part of the rural economy of India. A strong relationship has always existed between forests and the life, culture and economy of the great multitude of rural populace. This relationship is still stronger in case of tribals who sometimes depend entirely on forests and the occupation they provide.'

He further adds :

'Devastation of forests, by and large, has also resulted in dust storms, floods, erosion and abandoned farms, leading to scarcity and poverty in rural areas. However, the need to treat the vegetative cover with consideration has been realised, although relatedly, through sad experience.'

He again says that :

'It is also of interest to note that the average annual damage to houses, crops and public utilities due to floods from 1953 to 1974 was Rs 1680 million and the maximum damage recorded in any year (in 1971) was Rs 6310 million . The task of flood control becomes particularly difficult since excessive silt deposition, caused by soil erosion in the catchment areas, raises the beds of rivers, which easily overflow during the monsoon. ...Forests with normal ground cover give the best protection against both soil erosion and loss of moisture. Presence of vegetal cover acts as a mechanical deterrent to the development of floods resulting in smaller run-off and reduction in water velocity. The secret of protecting agricultural crops, life and other property lies in the maintenance of well-wooded covers. The leaves of trees only are capable to meeting the challenge of the raindrops.'

B. P. Pal, a noted environmentalist, wrote in his book captioned 'Environmental Conservation and Development' (1982 : 39) thus :

'One of the most disturbing features all over the world during the past few years has been the colossal and rapid destruction of forests. Trees are among the most splendid manifestations of plant life on earth.'

We can never afford to forget what Lord Buddha has said :

'The forest is a peculiar organism of unlimited kindness and benevolence which makes no demands for its sustenance and

extends generously the products of its life activity, it affords protection to all beings, offering shade to the axeman who destroys it. Forests not only beautify the earth but they also influence the climate beneficially and provide man with so many of his necessities.'

IV

Since studies of this kind were not carried out in this state or elsewhere in the country, the author was confronted with difficulties and very little to draw upon. Literature and records in related areas of this study were not readily available. Government officials, members of Public Institutions and villagers were interviewed. Discussion with them has been very useful. The forest staff extended their ungrudging help towards the research project. The fieldwork was hampered by ruthless and indiscriminate felling of trees for fire-wood and pilferage of forest produce by villagers. There are groups of people who benefit from felling of trees or killing of animals and their number is much more than those who want to maintain ecological balance. This study goes against the interest of the people who benefit from felling of trees and killing of animals. That has been the most serious impediments which should be kept in mind while discussing the results of this study.

1

Indian Forests

According to Willis (1951), forest is defined as 'a closed assemblage of trees allowing no break in the overhead canopy ; homogenous of one species, or diversified', while in the British Commonwealth Forest terminology (1953), it is called 'a plant community predominantly of trees and other woody vegetation usually with a closed canopy'. This definition is a slight modification of the term adopted by the Society of American Foresters. The definition as given in Indian Forest Record (1936) runs as follows :

'...an area set aside for the production of timber and other forest produce or maintained under woody vegetation for certain indirect benefits which it provides, e.g., climatic or protective.'

Forest signifies as part of the ecology a complex organism, composed of distinct biological units that have come into being by the combined action, reaction and coaction of a variety of organisms with the complex factors of the habitat that change themselves, in space and time. According to Toumey and Korstian (1947 : vii).

'...forest vegetation is composed of plant communities or units of vegetation developed and arranged in accordance with definite biological laws and is not an aggregation of trees and other plants brought together by change.'

The first land-plant in India appeared in Silurian period, i.e., about 440 to 480 million years from now and in course of one hundred million years, it evolved into various genus and species, of which fossil evidences are commonly found in different parts of India. Before going over to that, it is necessary to try to look into the geography of India as it was prevailing then.

Notwithstanding controversies on the nature of Indian geography, India was accepted as forming, part of a huge Continent styled as the Gondowanaland. It comprised present-day India, Africa, South America, Australia, Malayan Archipelago and Antarctica. Some geologists maintain that they did not form into a comprehensive land-mass, but were connected with each other by some land corridors across the seas.

It is believed that the forms of the same species in different parts of the globe did not evolve at the same time, but moved in different directions through migrations after they grew in one place. Carboniferous plants and animal fossils of Gondowanaland show a striking similarity. This could not have been possible unless migration had taken place.

In the Carboniferous period, this huge Continent of Gondowanaland was subjected to a cold wave with formation of ice and, consequently, glaciers. The Continent was skirted by sea, styled as the Tethys, which existed spatially where today stands the Himalayas. During this period of arctic climate, ice-caps formed on the huge mountain system, Aravallies of Rajputana ; and glaciers travelled North to Salt Range and Hazara. Another set of glaciers from Eastern Ghats travelled West to today's Andhra Pradesh and also North-West to Orissa and Damodar Valley regions. Within a few thousand years this cold wave, was hounded out by a climate which was tropical and indirectly responsible for bringing about revolution in the plant and animal kingdoms.

The forests in India, during the Permo-carboniferous period, i.e., about 350 million years to 225 million years back, were so gigantic and novel that they may easily be called the 'golden age of forests' in the geological eras. The rich and huge deposits of Gondowana Coal, estimated at 70,000 million tons, were produced from these forest areas.

The biggest single plant group recorded from these forests was Pteridospermeae (seed ferns). These were the earliest seed plants recorded so far. The seeds were, however, primitive. The earliest members of Pteridospermeae family that appeared on the Indian scene were *Gangamopteris cyclopteroides* and *Glossopteris indica.* This group was vascular, woody and some of them had underground rhizome. A fossil collected, viz., that of *Vertebraria indica* is supposed to be the rhizome of the *Glossopteris.* Some other species of this group collected from the Gondowana beds

are *Glossopteris indica*, *Glossopteris communis*, *Glossopteris decipiens*, *Glossopteris longicaulis*, *Glossopteris ampla*, *Glossopteris retifera*, *Glossopteris browniana*, *Glossopteris stricta*, *Glossopteris tortuosa*, *Glossopteris formosa*, *Glossopteris divergens*, *Glossopteris conspicua*, *Gangamopteris whittiana*, *Gangamopteris angustifolia*, *Gangamopteris hughesi*, *Gangamopteris kashmirensis*, *Gondowanidium validum*, *Sphenopteris polymorpha*, etc. In addition to this group, those archaic forests had scions of the ancestors of the present-day equisetums.

Another group of plants that was associated with Pteridospermeae was Cordaitales. The names of the species recorded in India have been *Noegerrathiopsis hislopi*, *N. stoliczkana*, *N. whittiana* and *Dadoxylon indicum*. *Dadoxylon* wood fossil of 24 metre long has been retrieved from Raniganj-Jharia coalfields. Primitive Lycopodes (club moss) were also present and woody trees of this variety became an important associate of the forests during the period. *Bothrodendron* was a genus recorded in Gondowana beds.

Besides, there were a few representatives of ancient Coniferales like, *Buriadia sewardi*, *Moranocladus oldhami* and, may be, a few Ginkgo like, *Psygmophyllum haydeni* and *Rhipidopsis ginkgoides Spenophylalles* were represented by *Sphenophyllum speciosum*. There were stray representatives of *Cycadophyta* like *Taeniopteris danaedoides* and *T. feddeni*.

During the Permo-carboniferous period, swampy forests composed of forms of now extinct Pteridospermeae and ancient woody trees or tree forms of Cordaitales, Lycopodiales and some forms of Cycads and Conifers were distributed in Central, Eastern and North-Eastern India, and probably in a part of South India as also in Western Rajputana, Kutch, Kathiwar, Salt Range, Hazara regions.

This glorious humid forest-period was followed by the dawn of Mesozoic era. The swampy forests were mostly destroyed. Pteridospermeae, the main group occupying terrestrial India, lost in competition. Groups like Cycad and Filicales had few representatives today. The forests that again had sprung up, amidst aridity and a less exacting climate, were not so extensive as those in earlier period, but nonetheless significant. The coal-seams produced from these forest lands were not very thick, but the geography and distribution of the forests were more or less similar. According to Sahni, B (1962 : 151), the plant-fossil bearing

upper Gondowana beds are now in numerous places in India over an area of about 10,240 square kilometers.

As stated earlier, the most important groups that composed the forests of this period were Cycadophyta and Filicales. In addition, Coniferales and Gymnospermaes had evolved and occupied forests in combination with others.

It will be interesting to note here that during the Mesozoic era, India had most varied forms of reptiles, including the Dinosaur. These Dinosaurs and those of that ilk were found in different beds in the Central India and it may be presumed that they may have lived in afforested zones. This may be so in spite of their food habits being not alike. Quite a few forms were possibly herbivorous according to Glenn L. J. (1964 : 229-230). The weight of an adult Dinosaur was supposed to be about 50 tons. It took this form from a tiny egg which did not normally exceed 20 centimeters in length. Therefore, it must have been necessary for the Dinosaur to devour an enormous quantity of vegetation during its life time.

II

The Gondowana period, spread over 250 million years, ended about 120 million years from now, with the beginning of movements of far-reaching mountains and volcanic eruptions in India. During volcanoes, so much lava was erupted in the whole of the peninsula that still about 5,12,000 square kilometers including Bombay, Kathiwar, Kutch, Madhya Pradesh and part of Deccan Plateau have traps as the major geological formation. The great Tethys also started shallowing up gradually during the period and by the end of Tertiary period, formed the landmark of the Himalayas that we see today. This volcanic activity and erogenic movements brought about such breathtaking change in the distribution and composition of forests that groups of Gondowana plants existing in the pre-orogenic period were wiped out.

According to Good, Ronald (1956 : 56), tertiary forests of India saw the virtual disappearance of Gymnosperm and entry of the Angiosperms, which has about a quarter of a million species today. In India, unfortunately, systematic work has not so far been done in fluviatile facies of the Tertiary era and, as such, no detailed report on the distribution of Tertiary forest can

be had. Secondly, the fluviatile facies has not been well developed in Tertiary, except in Assam, parts of West Bengal, Deccan Plateau, Rajasthan and parts of North-West Himalayas. This is because the area under fluviatile deposition was comparatively small as at present. The Himalayas were still under the sea in the early part of the Tertiary period, and Sind and Baluchisthan were getting marine depositions. An arm of the sea also extended right up to the Jaisalmer and Bikaner of Rajasthan.

Presence of lignite beds and coal-seams in certain parts of India indicates that extensive forests existed during the Tertiary period. At Tiruvakkarai near Pondicherry, Angiospermous wood fossils, viz., Peuce schmidiana of 18 to 20 metre long and 1 to 2 metre in girth have been recorded. The trees also having affinities with *Albizzia sp.*, *Mangifera sp.*, *Shorea sp.*, and *Terminalia sp.* have been recorded from later Tertiary beds. A few Gymnosperms having close resemblance to *Podocarpus latifolia* have also been found. In the inter-trappean beds of Deccan, Sahni, B collected species of plant-fossils having close resemblance to *Nypa fruticans* and *Lythracea*. All these point to the fact that the climate in the period was quite tropical, the conditions were estuarine and forest areas were extensive in parts of Deccan.

Further North, in Rajasthan area during the latter part of Tertiary, fossils belonging to Guttiferae have been discovered. The *genera* recorded show close affinity to *Mesua*, Garcinia *Calophyllum*, some of which are found in extremely wet condition today. It is clearly established that estuarine and moist conditions prevailed in the West Rajasthan area making it suitable for growth of dense forests, but conditions changed with the gradual regression and shallowing up of the arm of the sea.

III

The Tertiary period was followed by a period of glaciation throughout the globe, and India was no exception. It has been indicated by De Terra from his study of Kashmir glaciation that there had been at least five glacial advances during Pleistocene period, starting about a million years from now and ending at B.C. 25,000. These advances were intervened by inter-glacial periods when the climate became less cold. This caused lowering of quite a few mammalian species and also for extinction or

migration of Tertiary and Siwalik flora. W. T. Brandford supported the theory that during this period the climate in peninsula also became temperate and even now sites are present in peninsular plains containing certain plants and animals which are found entirely in the Himalayas or in the higher mountains in the lower latitudes. Species of Rhododendrons are the cases in point. It has been calculated by Burkill that equal to about 40 genera have perhaps migrated to South India due to glaciation in the Pleistocene period. Study of the Karewa formation of Kashmir of Pleistocene age records pollens of various *Coniferae*, *Gnetaceae*, *Graminae*, *Salicacae*, *Betulacae*, *Juglandacae* which are also found in the present Himalayas.

The culture of early man has been studied by Palaeo-Anthropologists. They have subdivided the period into Palaeolithic, Mesolithic and Neolithic cultures. These cultures have been studied in terms of achievements in respect of production of implements and, therefore, not suitable for our purpose. The Palaeolithic age corresponds, more or less, to the Pleistocene period of the geologists already discussed earlier. The Mesolithic and Neolithic periods correspond to Holocene or 'Recent' of the geologists' era. It has been found that the Holocene stone industries had fairly wide distribution in India, extending from Peshawar in the North-West to Tinnevalley district in the South-East India and also from Karachi in Sindh to Seraikala in Bihar. Indication is available to suggest that human cultures, in primitive and archaic form have gradually started disseminating themselves in different parts of India. This was followed by proto-historical period, when man learnt about agriculture without an equivalent interest in forestry. This proved detrimental to forests.

The proto-historic period in India starts with Mohenjodaro, Harappa civilizations in Sind and Punjab. It is presumed that Mohenjodaro civilization dates back from 5000 B.C. to 4000 B.C. This civilization was supposed to be urban and was distributed over parts of Sind, Punjab and Rajputana. The primary food for this urban population was agricultural produce. They had houses made of burnt bricks. As a matter of fact, from the excavations made in different places, e.g., in Mohenjodaro, Harappa, Rupar, Bikanir of Rajputana, Rampur of Kathiwar, etc., lakhs of burnt bricks have been recovered. The study of woods, recovered from different excavated areas including the

ones from cemeteries, constitute Deodar (*Cedrus deodara*), Pinus (*Pinus* spp.), *Dalbergia latifolia*, *Zizyphus* spp, etc. The Deodar and Pine woods must have been obtained for construction work from the Punjab mountains, perhaps by floating. *Dalbergia latifolia* and *Zizyphus jujuba* must have, however, formed a component of the forests in this region. Some seals recovered from the excavations unmistakably bear images of Rhinoceros and Elephants on them. The inscriptions are so life-like that it may be fairly correct to guess the presence of these species of animals at that time in those forests. The presence of Rhinoceros was detected in Peshawar even in 16th Century by Babur. It is possible to presume that Rhinoceros and Elephants were present in about 4,500 years ago in Punjab, Sind and Rajputana areas. The presence of *Zizyphus* spp., however, is indicative of the fact that the area was gradually becoming drier at that time even amidst forest conditions. Otherwise this species of xerophytic plant would not have grown.

IV

The Vedas, the Brahmanas, the Aranyakas, and the Puranas throw some light on the forest and forestry of India during those periods. One can make conjecture about their distribution and composition on the basis of description in the two great epics of the post-Vedic period, viz., the Ramayana and the Mahabharata. These, when read together with Panini's (700 B.C.) observations on forests, give us a fairly good idea about forest constitution and distribution in those days. Literatures are not scientific treatises, but constitute an important source material to get a glimpse into the dim and distant past not otherwise obtainable.

The Pandavas had escaped from Jatugriha and roamed about till their marriage with Draupadi in Panchala city was solemnised. They left Varanavata, now Benaras, or a place nearly on the bank of the river Varuna and went to Vatsa (near Allahabad region), Matsya (near Jaypur), Trigartta (Jalandar region) and Panchala (Bareily region), according to Ray Chaudhuri, H. C. (1927 : 39 to 42, 83). From the description of their itinerary in the Mahabharata it appears that in the south of the Ganga there existed a forest of one of the species of shorea robusta. In the Balakanda of the Ramayana, Viswamitra had taken Rama and Lakshmana

to different places, starting from Sarayu (now Gogra) and reached the confluence of Gogra and the Ganga. They crossed the Ganga and came across a huge forested region, Shahabad-Buxar area. According to description in the Ramayana this forest was full of lions, tigers, boars and herds of elephants. The species mentioned are *Dhab* (*Anogeissus latifolia*) *Sal* (*Shorea robusta*), *Bel* (*Aegle marmelos*), *Patal* (*Stereospermum suaveolens*) and *Ber* (*Zizyphus jujuba*). Consequently, it is perhaps possible that the forests of Allahabad region continued along the South of Ganga and merged into this forest in Shahabad-Buxar regions in those days. Today, the boundary of forests in Bihar is limited to Palamau district. The composition of the forest in Palamau is not much different from the one described in the Ramayana, excepting that Palamau forest must have in those days extended right up to the Southern bank of the Ganga. In the same episode it is found that Viswamitra was explaining to Rama the affluent condition of the 'forest-clad' Kausabmi kingdom. The Kausambi kingdom was a continuation of the forest mentioned before and was perhaps situated near the bank of the river Sone. These areas abounded in forests, a fact borne out in the Ayodhya Kanda of the Ramayana. Rama, Lakshmana and Sita crossed the Ganga near Sringaberpur (near Chaunar) and got into a dense forest. According to Bhattacharjee, T. K. (1960 : 217) they started moving westward, towards the confluence of the Ganga and the Jamuna. They discussed among themselves thus :

'We must be nearing the confluence of Ganga and Jamuna. Can you hear the sound created by clash of waters of two rivers ? See that the forest labourers have split timber branches.

This description of nature includes the following according to Bhattacharjee, T. K. (1960 : 221) :

'Baidehi, look around. With the advent of spring, the Kingsuka (*Butea monosperma*) with their flowers have set the whole mountain on fire.'

From here Rama went to Dandakaranya. This *aranya* (forest) was supposed to have extended from South of Vindachala of today to Malyaban mountain in the West. In the Ramayana these forests are depicted as dense, full of trees, shrubs and herbs inhabited by a lot of wild animals. In the Nala-Damayanti story, in Vanaparva of the Mahabharata, this area has been described in great detail. In this episode, the areas described are mainly

Chedi, Vidarbha, Nishad, i.e., Indore, areas of Vindya Parbat, Aurangabad, etc. When Nala left Damayanti somewhere in the North of the Vindya Parbat, Damayanti saw all around her a dense forest region with Cicadas making noise. Brihadaswa describe the forests as full of lions, buffaloes, tigers, bears, deer, etc. Trees like *Shorea robusta*, *Ficus sp. Butea monosperma*, *Salmalia malabarica*, *Terminalia arjuna*, *Ougeinia dalbergeoides*, *Ximenia aegyptica*, etc., were found there in abundance. Damayanti moved further eastward and entered into a denser forest through which she reached Vidarbha.

The Southern India or Deccan is described well in the Aranya Kanda of Ramayana during the search for Sita as also during Rama's journey to Sugriva's place near Pampa river and to Kishkindha. That most of these areas were forest-covered is evident from the description of the route by Kabandhya to Rama according to Bhattacharjee, T. K. (1960 : 435). The road from Panchabati (near Nasik) to Pampa river (Tungabhadra) was 'mountainous and forested'. The trees consisted of *Eugenia Sp.*, *Buchanania latifolia*, *Ficus infectoria*, *Asok* (*Saraca indica*), Kadam (*Anthocephalus cadamba*) etc. The road from Pampa to Kishkindha (Bellary) was also forested and was the habitat of elephants, tigers and deer population.

In North-West India the presence of 'Sal' forest on either side of the Saraswati river, once a most significant feature, is now extinct. In Aranyaka Parbadhyaya, the Pandavas started from Indraprastha and moved westward from Kamyakavana according to Singha, K. P. (1883 : 8). The description is as follows :

From Ganga they moved to Kurukshetra. In due course, they crossed Saraswati, Drishyabati and after taking bath in Jamuna, they halted in the Kamyak forest on the side of the river Saraswati.

Mention is made of Sal forests on the bank of the Saraswati river, like Daityabana. Description of forests included trees such as *Cinnamomum tamala*, *Borassus flabellifer*, *Madhuka latifolia*, *Terminalia arjuna*, etc. The regions near Virata had started becoming desolate. This was expressed in the inability of Virata King to maintain of his huge cattle stock. Nowhere this is so clearly expressed as in Go-harana Parbadhyaya of the Mahabharata.

Apart from these forests, existence of some sacred forests was

already known. It will be worthwhile to quote here from Bimala Churn Law (1944 : 41) of his book entitled 'Historical Geography of Ancient India'.

According to the Devipurana (Ch. 74), there were nine sacred forests (Aranyas), namely, Saindhava, Dandakaranya, Naimisa, Kurujangala, Utpalaranya (or Upalavrita-aranya), Jambumarga, Puskara and Himalaya. The Dandakaranya, according to Pargiter, comprised all the forests from Bundelkhand to the Krishna. According to the Ramayana (Uttarakanda, Ch. 81), it was situated between the Vindhya and the Saivala mountains ; a part of it was called Janasthana. Ramchandra lived here for a long time. According to the Uttara-Ramacharita (Act 1), it was placed to the west of Janasthana. Some hold this forest to be the same as Maharashtra including Nagpur. The Lalitavistara refers to the Dandakavana in the Daksinapatha. This forest remained burnt for many years. Even the grass did not grow there.

Panini mentions existence of artificial forests during this period. The natural forest was *aranya*, similar to Aranyani of Katyayana. The second category, he says, was artificially-created forest gardens and mentions Amrabans, Khadirabana (timber producing forest), Osadhibans, Debdarubana, Sirisbana, etc. Panini also tells about a number of trees, grasses and weeds.

There were *Sukracharyas* to look after the reserved forests. He says, 'Candana forest in South India yielded a large variety of aromatics and was protected by Gandharas'. Evidence of such protective activity, is available in Sugriva's famous Madhubana being well protected by Dadhimukha. However, reclamation of forest areas was continuing at a fast pace as E. P. Stebbing mentions :

'The ancient epic Mahabharata tells the burning of the Khandava forest. This forest appears to have been situated between the Ganga and Jamuna rivers and the description gives the first semi-historical evidence of the destruction of forests by the early settlers. The legend relates that the burning of the forest was only carried out with great difficulty owing to the frequent rains which Indra poured down to quench the fire.'

He continues : The prodigious road making endeavour (by king Bharata) from Ayodhya to the bank of Ganges en route to Dandaka forest involved a large-scale clearance of wild tracts. There was also a lot of use of forest timber and Jatakas as

quoted by the Cambridge Translation of Jataka indicate that there stood near Benares a great town of carpenters containing a thousand families.

Considerable amount of timber was presumably exported from India to distant countries, as Mr. Rassam found a beam of Indian Cedar in the palace of Nebuchadnezzar (604-562 B. C.) at Birs Nimrud, part of which is now exhibited in the British Museum. And again, 'in the second storey of the Temple of Moon-God at Ur, rebuilt by Nebuchadnezzar and Nabonidus' (555-538 B. C.), Mr. Taylor found two round logs of wood, apparently teak, which ran across the whole breadth of shaft. Mr. Rassam mentions it in a letter (according to Radha Kumud Mookherji, 1912 : 86-87) :

Most probably the block of wood which Taylor discovered was Indian Cedar like the beam discovered in the palace of Nebuchadnezzar. There is no doubt that this wood was imported to Babylonia from India.

According to Wilkinson, the use of indigo, tamarind wood and other Indian products has been found in tombs of Egypt.

V

The next period is of Greek invasion and Maurya kingdom. Information has been pieced together from the descriptions left behind by Herodotus (484-431 B. C.), Megasthenes (305 B. C.), Eratosthenes, Aristobolous, Strabo (60 A. D.), Aarian, Nearchos. In addition, information is also available from Kautilya and the Memoirs of Asoka. Whatever information is available from the Greek historians and geographers is mainly connected with Punjab and Sind and very little about other parts of India. The description as left behind by Herodotus leaves no doubt that it concerns with the Indus valley, bounded on the east by the desert of Rajasthan. Herodotus says :

'That part of India towards the rising Sun is all sand ; for all the people with whom ever we are acquainted, the Indians, live the farthest towards the east and, the sunrise of all the inhabitants of India, for the India's country towards the east is a desert by reason of the sand.

The Punjab area was, however, different. Aarian describes the regions to the east of Jhilam while writing the history of the

movement of Alexander's infantry, according to Stebbing E. P. (1921 : 30) :

'The forests there extended over almost a boundless tract of country, shrouding with umbrageous trees of stateliest growth and of extraordianry height ; that the climate was salubrious as the dense shade mitigated the violence of heat and that copious springs supplied the land with abundance of water.'

Stebbing E. P. writes : '...for we are told that the salt range and the country on the banks of Jhilam were clothed in forests, dense enough to conceal the movement of Alexander's army. The upper Indus plains were also clothed with forests and either banks of Jhilam grew forests enough to allow Alexander to build his Indian flotilla by which he moved south towards Sind and Musicanas'.

The composition of the forests is available from what Diodorus Siculus writes :

'Alexander having gained the splendid victory (over Porus).... As the mountainous country adjoining produced much well-grown Fir (Abies Sp.) and not a little Cedar and Pine besides an unlimited quantity of other kinds of timber fit for building ships he prepared what ships he required.'

Megasthenes gives a description of India during this period thus :

'India has many huge mountains which abound in fruit trees and many vast plains of great fertility, more or less beautiful but all alike intersected by multitude of rivers....'

VI

In memoirs of Hiuen Tsang this area was mentioned having a good climate, but scarcity of trees and plants, indicated a good deal of desiccation and deforestation in these regions now turned absolutely barren. Hiuen Tsang said 'oxen and sheep were numerous and fruits and flowers were scarce, the climate was hot'. During the Mahabharata period, Bairat king was rearing up a large cattle population. Apparently, this tradition continued until deforestation made fruits and flowers scarce.

By 600 A.D. a sizeable part of this area had become denuded of trees and plants. In the northern zone, forests were dense as recorded by the Chinese traveller, while moving South-West from Prayaga to Kasambi. He stated he 'went through a forest

infested by wild elephants, and after a journey of about 500 li* reached Kosambi'.

In the eastern region, he found deep forests in Sravasti, Kapilabastu and in the nearby regions, including Ramgram. From Ramgram, according to Rhys Davids, T. W. and Bushell, S.W. (1904-05 : 25) :

'...he went North-East through a great forest road being a narrow dangerous path with wild oxen and wild elephants and robbers and hunters, always in wait to kill travellers, and emerging from forests he reached the country of Kushinagara.'

The historic traveller had found good climate and cultivation in Vaisali, Vriji, Magadha, etc., as also abundance of flowers and fruits. But, in the huge mountain near Rajgriha (Paresh Nath ?), '...among its sombre mass of clouds and poisonous snakes and fierce dragons larked in the hollows of marshes—fierce beasts skulked and birds of prey roosted', according to Rhys Davids, T.W., etc. (1904-05 : 107).

In this mountain, he also came across lots of bamboo forest. His description of nearby hills includes a hill with two peaks 'whose sombre gorges were covered with vegetation', and again, 'a tall isolated hill well wooded and abounding in flowers and streams'. The hilly mountainous regions near Rajgriha were covered with dense vegetation and wildlife. From these areas Hiuen Tsang went through hilly forested regions to reach I-LAN-NA-PO-FA-TO (near about Mungheyar). In his journey further east, he recorded the presence of herds of wild elephants on the south of KA-CHU-WEN-KILO (Rajmahal). The legendary traveller crossed PUN-NA-FA-TAN-NA or Pundrabardhana (Pabna area, according to Cunninghan or Rangpur, according to Ferguson). These are all derived from Rhys Davids T.W., etc., (1904-05 : 173 to 198).

From the descriptions of the traveller it appears that the whole of the southern region consisted of forests punctuated by some human habitations. In his journey from Nagpur to AN-TO-LO (Andhra) and then to TE-NA-KA-CHE-KA (Amaravati, near Krishna river), about 1900 li or about 240 miles he found the routes mostly covered with forests. Near Amaravati, the pilgrim saw a desert-like place. CHU-LI-YA (Nelore or Kurnul region),

* 8.5 li makes about 1 mile.

according to the traveller had a sparse population. It harboured a forest for about 1500 li which extended up to south Malabar region, covering Madura, Tanjore, Coimbatore, Cochin and Travancore. Hills in this forest were supposed to have sandal, camphor and such other trees. He travelled from these regions through KUNG-KAN-NA-PU-LO (somewhere in Mysore-Ferguson) to Maharashtra and again through dense forest areas. Hiuen Tsang indicated that the forest actually died out near Bharoach and the tracts in Malawa and Atali on the North-West of Malawas were mostly sandy and salted and therefore it grew very little vegetation. The Surata terrain was mostly desert-like and the Sind regions were also wild and rugged.

VII

It appears thus that during 600--700 A.D. the forests were dense in the Himalayan foot-hills, particularly in present U.P., Bihar, some areas of Assam near Tripura, in the Allahabad-Rajmahal zone, Dandakaranya forest areas and also in the Deccan. The Western India from Bharoach and northwards, including Rajputana, was hot and scarcity of trees was noticed by the Chinese traveller. Agriculture flourished, according to him, in the Indo-Gangetic alluvium of U.P., Bihar and Bengal.

From the reign of Babur till the era of East India Company, precious little is found about the detailed description of forest area and its distribution in India. Yet, during this period Indian subcontinent attained extremely important growth and reclamation of land for agriculture took place at a comparatively faster rate. Abul Fazal in his *Ain-i-Akbari* calculated actual agricultural area in each Subah during the reign of Akbar, but detailed analysis of those data is fraught with the danger of wrong result. A number of attempts was made by the British Rulers, viz., Eliot and Beams to give comparative statistics with a view to making out the figures of an individual modern administrative district, corresponding to that existing at the time of Akbar. A relevant excerpt from Vincent A. Smith (1962 : 291) is quoted here :

'In certain cases, as in that of Sirkar Mungir in Bihar, the Ain omits the figures of area altogether and... many local officers have attempted the task and attained only partial but admittedly only partial success.

An accurate quantitative statement of forests or agricultural area of Akbar's period is out of question. But, it is important to indicate that there was a lot of incentive for increasing the area of agriculture, and that obviously by reclamation of forest areas or by cultivating the fallow land. Below is given a relevant quotation from Cambridge history of India in 'The Moghul Period' Volume IV, Cambridge :

'To attract peasant to vacant land, to induce peasant, to extend the area tilled, to secure improvement in the class of crops grown, these were the permanent ideals, though in practice they might even be marked by the need or greed of the moment.'

A project was taken up for land, reclamation within 5 years, when the full revenue demand would be paid on completion by the peasant (1/3rd share), only 1/26th of which is payable in the first year. This financial incentive boosted up the reclamation work, but reclamation was not so much as to deforest the sub-continent. Oldham writes about cultivated spaces in the forest in the early days of Mahommedan period. The record of abundance of forest in different parts of India as far back as in 1616 to 1619 is available in the journals of Edward Terry, a Chaplain in the court of Akbar. William Foster states, '... the whole kingdom is, as it were, a forest, for a man can travel no way, but he shall see them and (except it be within a small distance of the king) they are every man's game'.

Babur used to write detailed journals. His illuminating description of India is worth quoting : According to Leyden, John :

'Hindusthan is situated in the 1st, 2nd and 3rd climate. No part is in the 4th. It is remarkably a fine country. It is quite a different world compared with our countries. Its hills and rivers, its forests and plains, its animals and plants, its inhabitants and the language, its wind and rains, they are all of different nature. They have abundance of strong grass and plenty of timber with which they make hovels, and a village or a town is constructed in an instant. All these suggest that India is still a country with a lot of forest areas and abundance of timber resources.

The northern zone had by now turned into the Rajasthan desert. With all its fury this desert further continued westward and made the whole of southern Sind a dry desert place. This area was naturally connected with Geodrosia desert as described

by the Greek historians during the invasion of Alexander. Vincent Smith (1962 : 188) has quoted the missionaries going to Akbar's Court in 1594 saying that most of the countries between Cambay and Lahore were sandy and desolate and the missionaries did not reach the prosperous fertile regions until they were within 60 leagues of Lahore. Water was scarce and brackish, being often nearly as saline as sea-water. Nicholas Withington, while going to Lowry Bander (Lahribandar, the old port of Tatta near the Piti mouth of the Indus) from Amadabar (Ahmedabad) described hill regions, according to William Foster :

'... desarte ... . There beeinge nothinge bee had on the way, no soe much as freshe water for our Cammells, nor any other victualls for them or ours...in the desarte that wee had passed we saw greate abundance of wilde Asses, Red Dens, Foxes and other wild beasts.'

In this Subah again the eastern regions, viz., Garha Sarkar had a number of woods infested with wild elephants. The Sarkar of Bijagarh in the Subah had numerous wild elements too. At the same time, this Subah having a measured land at 1079514 hectares yielded a revenue of Rs 60,17,376, a substantial amount in those days. Consequently, it may be argued that Malwa region was being gradually reclaimed for agriculture. The Gujerat Subah in the South-West of Rajputana desert was again found with sandy soil. Even though there were low woods with leopards as mentioned by Abul Fazal, the forests were of desert type. It is here that in March of 1567 A.D. Akbar organised an enormous battue of big games before leaving Lahore.

This forest was extended further west to Jhelum as a similar battue was arranged by Akbar in Bhera on the bank of the Jhelum on 20th of April, 1578. Perhaps this zone continued till Peshawar and Hasnagar of Kabul, as Babur says in his journal, '...in the course of my expeditions I frequently killed the rhinoceros in the jungle of Peshawar and Hasnagar'. To the east of Rajputana lay Delhi and Agra Subahs. Agra Subah was described by Abul Fazal as having a perfect agriculture with fruits and flowers abounding. The area was mentioned as 6999543 hectares yielding an annual revenue of Rs 13,656,257. Babur, however, in his description of Hindusthan mentioned Kalpi Sarkar on the bank of Jamuna to the west of Allahabad, included by Abul Fazal in Agra Subah having a lot of wild elephants. As

a matter of fact, from his and other descriptions of this region, it appears that the huge forested zone of the Eastern India, including that of Orissa, started from Kalpi, i.e., the eastern regions of Agra Subah. In Delhi Subah, the western portions having Thaneswar, Saraswati river and Kurukshetra, etc. were no more forested area, according to the descriptions of Hiuen Tsang. But, the north of this Subah, viz., Kumaon Sarkar and in the east Chambal Sarkar were still heavily forested and contained wild animals, as described by Abul Fazal. These forests abounded in big games, including musk deer in Kumaon and rhinoceros in Sambhal.

The Mughal policy on forests was one of indifference. They had no regard for the forests, nor any religious scruples for destroying them. The forests were reclaimed for agriculture on which emphasis was laid. The State had supported this through incentives given for the purpose. A part of the population which lived on agriculture was driven back to forests by the Mughal invasion. There they took to the method of shifting cultivation, a pernicious system, probably as destructive to forests as any other act of man. The Mughal emperors took fancy in having buildings constructed with stone and, as such, requirement of quality timber for State hierarchy was considerably less.

Besides, the Mughals looked upon forests as game preserves for the purpose of sports. Secondly, they were interested in trees for gardening and also for plantation in either side of the avenues. In short, they had aesthetic and utilitarian approach to plants, without any comprehensive understanding of forestry, its preservation, propagation, protection and improvement.

VIII

The end of the Mughal period was followed by the beginning of the East India Company Rule and later, by the British Rule. In the eighteenth century and up to the middle of the nineteenth century, some parts of Indian forests were subjected to exploitation on a gigantic-scale for shipbuilding and railway sleeper production, without any concomitant attempt being made for forest preservation. West Bengal forests were spared from this ravage, because the forests in the western districts were under private zamindars. There were not many timbers there too. North Bengal forests were still under occupation of the allies and

accessibility being poor, their exploitations were uneconomical. Forest areas, however, shrank significantly during the British Rule because of the expansion of agriculture. The forests in Sundarbans alone shrank by about 2560 square kilometres, released for agricultural purposes in the last 200 years and 1280 square kilometres within the last 100 years. In the Malda district of then Rajshahye Division in 1864 there were two large tracts of forests, one near Malda city itself and the other at a distance away. Today, Malda district has only about 30 (thirty) square kilometres of forests. In the Rangpur district of the same Division was situated Bykuntpore Pergunnah ; there were 500 square kilometres of forests here which now stand at only 200 square kilometres. In the Burdwan Division, there were small forests in the districts of Bancoorah, Birbhum and Midnapore. The extent of Bancoorah forests was not mentioned, but it was said to have been covered with young *Sal* trees or rather scrub of very small worth which was not permitted to grow into trees worthy of the name of timber. Birbhum, however, had eleven tracts of forests situated in different regions containing large timber. The area of timber forests was estimated at 4453 hectraes. Today, the district does not have any timber forest worth the name. In Midnapore district, the Jungal Mahal had alone 3072 square kilometres in 1862, against the total of 1300 square kilometres over the area as at present. No statistics for North Bengal forests exist, but Anderson, the first Conservator of Forests, estimated it at 42510 hectares of Government forests alone in the district of British Sikkim. Leeds, the first full time Conservator, put it at about 59190 hectares in 1866. He took into account only the workable areas and his estimate cannot therefore be taken for granted with today's figures. From 1901-1964, however, the total forest area reduction was more than 256 square kilometres. The forest conservancy was started in Bengal in 1864 with the appointment of Dr. Anderson as Conservator of Forests. The first notification for reservation of forests was dated 14th December, 1864, but it is a different story. Be that as it may, of the net notified area in the then Bengal in 1903-04, 52·5% of the area was under agriculture, against 62.8% in 1951. This increase in percentage in the agricultural area was evidently at the cost of forestry, the total area of which was reduced by about 5120 square kilometres during the period. This tends to continue even today, but

on a different plane. Industries, mining, urbanisation, irrigation channels, dams, etc., are all gnawing into the forest area. Forest area is under threat of total annihilation. The per capita forest area has come down to 0·05 hectare by 1951 and ·02 hectare by 1986 in West Bengal, a figure woefully inadequate for a developing economy. This is against 0.12 hectares for India taken as a whole. Use of land is more intensive in developed countries but per capita figures show that USA has used 1.3 hectares, USSR 3.6 hectares, Canada 14.2 hectares and UK 0.04 hectares of land. A balanced land-use is called for in India.

IX

The per capita forest area in India today is barely 0.12 hectare, while the world average of the same is 1.0 hectare. The reason is not far to seek. India has lost forest areas over a period of 32 years from 1951 to 1983 to the tune of about 43420 square kilometres.

At present, land utilisation position in India is as follows (as per West Bengal Forest Statistics, 1984 : 10) :

Land-use	*Area in million hectare*	*Percentage of total area*
Agriculture	154.7	47.0
Forest	74.8	22.7
Cultivated land	43.6	13.3
Land under non-agri uses	17.4	5.3
Barren and unculturable land	38.3	11.7
Total	328.8	100·0

Classification of forest areas in India :

Legal status	*Area in million hectares*	*Percentage*
Reserved	39.01	52.2
Protected	23.21	31.0
Unclassed	12.56	16.8
Total	74.78	100·0

Ownership	*Area in million hectares*	*Percentage*
State owned		
Forest Department	69.74	93.3
Other Department	1.89	2.5
Corporate bodies	1.45	2.6
Private	1.20	1.6
Total	74.28	100.0

In the State of West Bengal, the land utilisation position as per West Bengal Forest Statistics (1984 : 9) is as follows :

Net area sown	63.3 per cent
Current fallows	1.3 "
Area under forests	13.4 "
Area not available for cultivation	15.0 "
Other uncultivated lands excluding current fallows	7.0 "
	100.0

2

Forest Policy

Forest, as a renewable natural resource, plays a key role in the general economic well-being of the country. It provides the requisite raw materials for industry, defence, communication, other public purposes and domestic use and contributes towards creating a large volume of employment in the primary, secondary and tertiary sectors of the economy. Materials for direct use, such as, fuel wood, small timber, fodder, grazing land, etc., are also available from forest. The benefits derived from forest in soil and water conservation, recreation, wildlife, forest produces, etc., have also been well appreciated.

The main demands on forestry are two-fold, viz., (a) supply of industrial wood and (b) supply of other forms of produce like fuel wood, fodder, recreation, etc., which are the minimum social needs in the country. The output of forest should be so planned as to meet these needs at a price the community can afford to pay. That will constitute the forester's contribution to the agricultural progress and to the creation of employment opportunities to large sections of tribal and other population living in and around these areas.

The whole range of forest organisation is required to gear in a way compatible with the developmental programmes. An a priori condition to this situation is the availability of man-power with appropriate training and background. The following salient points deserve special mention regarding the forest administration:

1. Forest lands have a distinctive character and require specific technical know-how as well as managerial capabilities ;
2. forest services, unlike other services in the allied fields of agriculture, are directed towards managing resources which often take a long time to yield results ;

3. forestry is a business and that its administration is different from that of Government Organisations known for providing services.

In our country forests being State-owned, forest administration is entirely the concern of the Government. Forests are required to be developed as potential resources to be managed in a business-like manner in order that an optimum production of goods and services, at the lowest cost, can be secured. A Forest Officer should, therefore, have an understanding of and training in, business management techniques. He must be capable of taking decisions on an analysis of the data at his disposal. He must know how to develop alternative solution, if necessary, to set goals, check on performances and evaluate results. In other words, the task of the modern forester is to determine goals and method of achieving the same, fix up persons to undergo necessary duties, and the time-limit within which the work should be performed.

The following setup should be adopted for the forestry :

(i) An elaborate government hierarchy should be avoided, in forest administration. If a particular forest produce is important as a trade item and it is necessary to entrust the management of that produce to a conservator of forests, there should be little scope to pass on the work to others below him like Deputy Conservators, Assistant Conservators, Forest Rangers, Deputy Rangers/Foresters and Forest Guards.

(ii) In jobs where a particular expertise is required, the setup should be such that there is no scope for passing on the work to others below. For instance, in photo-interpretation not a whole band of Technical Assistants, senior or junior, is necessary. If the workload demands, more photo-interpretation officers of the same status can be appointed.

(iii) Expertise for different disciplines of forestry should be built-up through proper selection, specialisation and training, without losing, as far as possible, a broad contact with other aspects of forest management.

(iv) There should be scope in personnel management policy to utilise continuously the expertise through a promotion on performance from grade to grade.

(v) The setup should be such as to help promote an integrated approach to production of forestry and utilisation of the resultant produce in forest-based industries.

(vi) The structure should be conducive to increasing involvement of the local for forest protection from illegal felling of trees and plants, excessive grazing and also for securing social justice.

(vii) Since services are field-oriented, the ratio of technically qualified persons to non-technical supporting staff should be high.

II

The forest organisation of the Central Government is headed by the Inspector-General of Forests (IGF). There are Additional and Deputy IGFs, Assistant IGFs, etc. Besides, there is the Director, Project Tiger and a host of other low-ranking officers and staff to help him.

The staffing pattern of the Forest Department consists of a five-tier hierarchy with the Principal Chief Conservator of Forests as the apex body. The State forest area is divided into Circles, each of which has been put under the charge of a Conservator of Forests, then into Divisions or Ranges, each under the charge of a Range Forest Officer or Forest Ranger, the Ranges into Beats held by Foresters and lastly the Forest Guards, the lowest cadre among the forest personnel, as defined in the rules under the Forest Act. This is the general pattern of the pyramidal setup, with local variations in the matter of designation and the territorial jurisdiction. Functionally, the Forest Guard assists in the task of the protection of the forest Beat, the Deputy Ranger/Forester is in charge of the protection of the forests and execution of works in the Beat, the Divisional Forest Officer is charged with the overall administration of the forests in the Division. The Conservator of Forests is at the intermediate level and serves as an Adviser and Guide to the Divisional Forest Officers and ensures proper implementation of the policy of the Government and the management and development plans sanctioned from time to time. The Principal Chief Conservator of Forests acts as a technical Adviser to the Government in formulating policy prescriptions and as a Chief Administrator in forestry matters.

In course of time, Special Divisions were created for silvicultural research, working plans, forest utilisation and conservation, etc.

III

In West Bengal forests have a chequered history. During the past centuries, as also in the early decades of the present one, the forests suffered widespread trespass and disintegration under the pressure of extensive agro-economic movement. The natural form and physiognomy of the forests have greatly altered with the changes in human history. The land-use pattern in the State, as elsewhere in India, emerged on the basis of physical and climatic conditions. The growth and migration of population in the different periods also contributed in no small way. The forests, as they exist now, are concentrated in three distinct regions, viz., (1) the Northern Montane and Sub-Montane region, (2) the Gangetic delta and (3) the Laterite tract in the South-West. Large areas in the Gangetic plains and other fertile systems are either bereft of forest patches or bear only a sparse and residual vegetation. Economic and environmental contributions of forestry vary widely from region to region, depending on the demand, utility of different species of wood and economic as well as physiographic situation in which they occur.

The constitution of Reserve Forests and demarcation of forest areas were followed by certain legal injunctions against reckless clearance of forests. Nevertheless, extensive marginal forests were left out adjoining the village sites and, for many of their needs, these forests used to be the principle source of supply. As time passed by, agriculture and settlements advanced at the expense of forests and the residual vegetation began to degenerate in the wake of intense exploitation. However, even when reduced to scrubs, these provided the major requirements of fuel, fodder and other necessities to millions of people.

In the past century, with scientific management of forests already introduced, conservation was the slogan. The foresters knew about the protection of environment and its promotion. The evolution of management underwent a slow but sure change. From the 'Selection System', it moved to the era of 'Clearfelling System'. Inevitably, much of it remains as it was many decades

ago, still much else is new ; conservation strategy for the first time was on trial.

Considering variety of environments and different linkages, villages can be put into the following broad categories :

(1) Mainly dependent on forests, and marginally on agriculture, e.g., the Himalayan region and similar other productive zones.

(2) Totally dependent on agriculture, as in the case of fertile river basins.

(3) Subsisting on agriculture and pastoral economy as in the dry laterite tracts.

IV

It will appear the picture is one of contrast. On the one hand, in thickly populated areas of the river basins forest lands are being utilised for production of food and, on the other, in sparsely populated areas extensive biological concentrations are found. Many peculiar intermediate situations exist between the two extremes.

Differences in terms of relative importance for development as revealed by three different regions need to be clearly understood. It is important to understand what makes them unlike each other in terms of their requirements of inputs for development. Disparities among the rural people living in the above-mentioned regions, and also between rural and urban settlements are perpetuated by inequitable distribution of developmental funds. In many cases, rural peripheries and largely unconnected with the urbanised and developed settlements. This is the result of administrative decisions and allocation of funds for investments. The inequitable regional development is demonstrated by the existence, within the State, of large depressed areas around the forests, as being mutually inconsistent with total development. Such a situation is likely to generate tension between the haves and have-nots. The have-nots might then resort to tyranny on the opulent class of people leading frequently to ethnic segregation and discontent. In the midst of normal cultural practices, usages and habits, signs of change are noticeable in the social setup.

Constitution of Reserve Forests in the past century, opened up new vistas of development. There was appreciation of many duties and obligations involved, viz.,

(i) how best the forests can be maintained and improved ;

(ii) what are the gains and hazards of systematic exploitation ;

(iii) what are the markets ; and

(iv) how best to meet the demands of various categories ?

Admittedly, the gains are many and varied, if proper initiatives were taken for conservation. Amidst the labyrinthine laws and regulations, it was possible to evolve a wide spectrum of demand and supply management to ensure proper use and development of forest resources. The depletion of mature stock and repletion with new stock started, as conservation of natural forests began in a very small way then.

Natural regeneration systems failed to evoke significant response and the crops all over were fast deteriorating. Faced with this situation, conversion of high forests by means of planting clearfelled areas was taken up by the authorities as early as in 1868. *Sal* (Shorea robusta) plantations in the plains and in the low land valleys, teak on the well-drained slopes and flats, miscellaneous plantations along the foothills in the Duars and Terai are results of many arduous trials and experiments. Similarly, in the hills, the plantations of a broadleaved tree complex as well as those of *Cryptomeria japonica* have been the outcome of human ingenuity. All these now as part of a tradition will continue to prevail in the forestry of the region.

However, the unbalanced pattern of sectoral development that characterised the growth of the forests is closely linked with the allocation of resources and management policies. So far, all the indicators of development go to show that manufacturing establishments have received disproportionately large shares of national investment for productive and social overhead expenditures. The adverse results of these policies on the productive capacity of forest have come to the surface. It is realised now that forest and rural development policies can restore the essential linkage between urban and rural societies, continuously ignored in the past development policies. Forestry is, thus, beginning to take into account a wholesome interest as part of a system.

V

To begin with, it is necessary to study the process of operation in the system before introducing any large-scale change through major developmental projects. The principal objectives of developmental planning of forestry are :

1. to link up forest resources with forest-based industries on the basis of physiographic, industrial and economic catchment concepts ;
2. to develop forestry as an ancillary support to rural economy, and to trigger off development (through cottage, small-scale, medium- and large-scale industries) in the backward regions, where forests happen to be the most important local natural resource.

The goal of forest development is the management of forest lands in a manner conducive to the production of goods and services as a continuous process towards enriching the lives of the people. It involves biological and economic considerations and includes both productive and non-productive aspects of forestry. Biological considerations are important inasmuch as it ensures sustained yield through proper management.

It is inappropriate to discuss forest management or the institutions which manage forests, without considering the political and social framework in which life is lived. An important aspect is the property ownership especially relating to land. In a country where land and ownership are vested in the Government, the range of benefits should be wide. The output of the society as a whole should be assessed rather than those of the entrepreneur alone. Account should be taken of social costs and benefits, and this should be reflected on the policies of many countries towards private forestry, under which the State influences the actions of private forest enterprises through control, technical assistance and financial support. In discussing the process of policy-making, C. E. Lindblom states :

'A comprehensive overview of factors relevant to a decision, clarity of definition of social objectives, a means-end approach to policy, deliberate and explicit choice among policies, a calculation and minimisation of cost, reason and cooperation rather than arbitrariness, coercion and conflict, a unified decision-making process for decisions that are highly interdependent.'

There is usually a difference between what should be ideally done and what is actually done. The important point about policy formation is the complexity of interactions in the given circumstance among economic and social forces. Direct State participation in forestry allows resources to be directed, in competition with other alternatives uses, to areas where social needs are most pressing. The importance of policy lies in the fact that the objectives, in the context of circumstances in which they are sought to be achieved, determine the criteria for resource allocation. The investment in forestry has been woefully inadequate and its contribution has been very small.

Although the forest-covered area is a little less than half of the cultivated area of the country, the contribution of the forest sector to the Net Domestic Product (NDP) is insignificantly small and is not commensurate with its potentiality. The investment in forestry has also been extremely inadequate. Even financial allocation for forest production programmes so far had been very small. This has resulted in low productivity from our forest resources.

One reason why forestry has made not much headway is that no continuous history is available of the entire forest tracts in many of the States as they exist now. There have been changes due to : (a) formation of new Provinces like Bihar, Assam and Orissa, prior to Independence ; (b) merger of the Princely States after Independence ; (c) formation of Andhra State in 1953 ; (d) large-scale acquisition of private forests belonging to different rulers of the States and private owners in the fifties ; (e) the general reorganisation of the States in 1956 and (f) the changes since 1960 creating many new States by reorganisation.

In 1921, the administration of the forests was vested in the Government of the Province concerned. With the grant of Provincial Autonomy under the Government of India Act, 1935, forests came completely under the State control. The Second World War affected forestry practices all over the country.

VI

The development of forest is expected to move along the policies adopted in the country. Before Independence, India had

a National Forest Policy enunciated in 1894 which runs as follows :

1. The sole object of forest administration by the State is public benefit. In general, the constitution and preservation of a forest involve the regulation of rights and the restriction of the privileges of the user in the forest by the neighbouring population ;
2. Forests situated on hill slopes should be maintained as reserve forests ;
3. Forests which are the reservoirs of valuable timbers should be managed on commercial lines as a source of revenue to the State ;
4. Where an effective demand for cultivable land can be supplied only from forest area, the land should ordinarily be relinquished without hesitation, subject to the following conditions :
   (a) Honeycombing of a valuable forest by patches of cultivation should not be allowed ;
   (b) Cultivation must be permanent and must not be allowed to encroach upon minimum area of forest that is needed to meet the reasonable forest requirements, present and future ;
   (c) Forests that yield only inferior timber, fuel wood or fodder and used for grazing, should be managed mainly in the interest of the local population.

The policy was based on the assumption that the forests serve agricultural interests more directly than before and that the claims of cultivation are stronger than that of forest conservation.

In the wake of this policy large tracts of forests in West Bengal had been vanishing even before these could be preserved. The National Forest Policy was on paper and not followed. Sir Joseph Dalton Hooker writes in Himalayan Journal that he arrived at Siliguri (now practically the geographical and administrative centre of Notrh Bengal) on the 13th April, 1848 and he caught what he describes as a glimpse of the Himalayas :

'Sombre masses of far from picturesque outline, clothed everywhere with a dusky forest and to east and west, as far as the eye could reach, were range of wooded mountains...clothed in dense deep-green dripping forest.'

The present picture is totally different. As far as the eye can reach, tea estates vie with forest to the East and West, and at many

points eclipse it. In the State of West Bengal what happened in reality was as follows :

1. Establishment and growth of tea estates in Darjeeling hills and the foothills of Duars.
2. Large increase in population resulting from working of forests, etc.
3. Clearing of forests for cultivation in the Darjeeling hills because of migration of population from Nepal. Centres of trade and commerce were opened. Return from the soil were diminishing.
4. Expanding communication networks through roadways and railways.
5. Disappearance of indigenous populace following import of cheap and productive labours from outside.
6. Gradual increase in the diversity of products from mangrove forests of Sundarbans because of extension of forestry and growth of Calcutta as a metropolis. The attitude of the foresters was hardened against the inroads of agriculture into forest tracts.

VII

Much water had flown down the Ganges between the period intervening 1894, when forest policy was first laid down, and 1952, when it was revised. Unreserved forests had disappeared, the population had exploded, the communications had tremendously increased and more and more forest-based industries started looking up to cater to the needs of the indigenous sources. Two Wars intervened and spurts of denudation of forest activities were noticed mainly in the over-felling of forests in the name of war supply. Following the aftermath of war and partition of the country, forest lands were quickly recovered. This period was more of consolidation of forests than of any other bold innovation. The distinctive features of the period having direct bearing on the economy of the forests of this State of West Bengal were :

(1) Development of the technique of artificial regeneration of *Sal* (Shorea robusta). Gross value of the forests and its annual increment were increased ;

(2) Teak plantations were broad-based in North Bengal.

This new policy of 1952 proposed the classification of forests on a functional basis into (1) protected forests, (2) national forests, (3) village forests and (4) tree-lands. It emphasised the need for evolving a balanced and complementary land-use system under which it would produce most and degenerate least. The policy considered it desirable to establish tree-lands, wherever possible, for the amelioration of physical, climatic and environmental conditions and for promoting the general well-being of the people. It also made provision for ensuring progressively increasing supplies of grazing-fields, timber for agricultural implements and firewood, to release cow-dung for use as manure. The national forests were to be managed on the principle of progressively increasing sustained yield to meet the requirements of defence, communication and industry. It also emphasised the need for affording protection for wildlife by its proper management and scientific study, and for recreational purposes. The policy laid stress on :

(i) weaning the tribal people away by persuasion from the baneful practice of shifting cultivation ;
(ii) increasing the efficiency of forest administration by enacting adequate forest laws ;
(iii) imparting requisite in-service training to the staff of all ranks ;
(iv) providing adequate facilities for the management of forest ;
(v) controlling grazing in the forest ;
(vi) the need for promoting the welfare of the people.

No concerted efforts were, however, made to bring the recommended 60 per cent of area under forests in the mountainous tracts liable to erosion, and 20 per cent in the plains. Hardly any of the principles on grazing in forests was implemented.

Since the enunciation of this policy in 1952, developments of far-reaching importance have taken place in the economic, social and political fields. Increase in population has given rise to diverse demands for a great variety of forest products on the one hand and has built up heavy pressure on land on the other. Substantial forest land has been lost in the silvicultural and management techniques. In technological vis-à-vis industrial fields considerable progress has been registered by opening up avenues for further expansion on integration of forest-based industries. Social forestry caught the imagination of the people

as a sound management concept. The cause of tribal welfare was espoused by ensuring fulfilment of their domestic needs of various forest products and by giving priority to their need for employment in forestry operations. Tribal dependence on forests may be classified as follows :

1. Economic dependence—in hunting, gathering cultivation, grazing, sericulture and arts and crafts.
2. Social dependence—clan organisations are totemistic and totemic objects are often forest-based.
3. Political dependence—tribal Panchayats were often held during the annual hunt.
4. Religious dependence—forests have moulded the religious and magical life of the tribals. They worship a number of jungle spirits and jungle gods.

The key to the future of forest development lies in a complete reorientation of outlook towards forestry practices and in the implementation of the conservation programmes. The Government should allocate adequate resources for investment in forestry, hitherto neglected, and promote social forestry as a part of policy prescription. It is necessary to revise the forest policy of 1952 to meet the requirements of time and the new policy of 1988 came into force.

VIII

The 1952 National Forest Policy had recommended one-third of the land area of the country to be maintained under forest cover for ecological reasons. But even the estimated 12 per cent of the land area under adequate tree, cover includes, besides degraded areas, extensive mostly monoculture plantations which do not serve the ecological functions of natural forests. For planning and programming for the extension of tree-covered area a vital consideration is that this extent of ecologically functional, or natural, forests are essential for the country. There should also be a programme for regenerating the mixed natural vegetation growth over extensive areas currently under monoculture planations.

Permanent pastures account for an estimated 13 million hectares. However, these areas are, in fact, generally without

any vegetation on account of either overgrazing or encroachments. In addition, 40 million hectares of non-forest lands are classified as either 'fallows' or 'cultivable wastes', and lack vegetal cover. This state of affairs has had and continues to have very serious environmental as well as socioeconomic consequences. The environmental consequences manifest themselves in accelerated erosion and landslides, premature siltation of reservoirs, decline in land production invasion of noxious weeds, severe loss of precious genetic diversity of our plant and animal populations and adverse inputs on micro- and macro-climates. Floods and droughts occur as a result of excess run-off from denuded slopes and result in the loss of vast quantities of irreplaceable top-soil as well as of water which could otherwise have been stored as groundwater. The loss of the tree cover also has grave socioeconomic consequences. Today, we are in the midst of severe shortages of fuel, fodder and wood for satisfying the basic minimum requirements of the people and face mounting raw material scarcity for forest-based industries. Pressures of population and the improverishment of rural and forest-dwelling people are increasing illicit felling and encroachment on forest lands. There is need to generate large-scale local employment in such areas in order to control the continuing movement of headloads of fuelwood from the remaining forests into urban settlements.

The major reasons behind the depletion of our forest resources over the last few decades have been :

The low priority for preserving tree cover in the face of political pressures for utilising forest lands for settling the landless and for the construction of dams, mines, and other development projects which cause forest destruction ;

Inadequate forest department staff and technical equipment to practise scientific extraction methods and to prevent excessive felling by forest contractors and damage by forest fires ;

Inadequate allocation of financial and managerial resources for afforestation and effective replenishment of fast dwindling forest resources ;

The replacement in many reforestation programmes of natural mixed forests with monocultural plantations, even in highly sensitive ecological regions like the Western Ghats :

Establishment of forest-based industries without due regard

to the viability of the resource base. This has led to heavy over-exploitation in certain areas, notwithstanding technical advice to the contrary ;

The tendency of industry to use forest resources in an ineffective fashion because of the very low prices at which these were, and sometimes still are usually made available by the government ;

Lack of incentive and legal restraints on private individuals willing to raise and maintain tree cover on their land ;

Intense human pressures on forests for fodder, fuel timber and agricultural land ;

Failure to involve tribal and local communities in the preservation and augmentation of forest resources and to remove the suspicion and hostility which exists between them and forest officials ; and

The absence of a reliable system for the collection and reporting of accurate data regarding forest resources. Thus, areas which have long since been stripped of cover or have been diverted to non-forest uses continue to be reported as 'forest' lands in statistical returns ;

The absence of a clearcut and unequivocal forest policy based on the twin principles of environmental stability and social justice.

The vital and permanent needs of the country are to be first recognised before a pragmatic framework is designed for a new forest policy. The policy recognises the following needs :

The need for the maintenance of environmental stability through preserving and where necessary restoring the ecological balance that has been adversely disturbed by an insufficient appreciation of the role of forests and consequently their rapid depletion ;

The need to conserve what remains of the natural heritage of the country through preserving the existing natural forests along with their vast variety of flora and fauna which represent the tremendous biological diversity and genetic resources of the country ;

The need for checking erosion along treeless banks of rivers, in the hot and cold deserts of Thar and Ladakh and their environs on large stretches of waste lands in the hilly and drier parts of the country ; on areas denuded of vegetation by shifting cultivation and on barren sea shores ;

The need for safeguarding and sustaining the welfare of tribal and other forest dwelling communities which are almost entirely

based on the use of various forest resources, through restoring their rights of access and control ;

The need for generating productive employment for the large number of unemployed and under-employed people in the rural sector in programmes of regeneration of degraded lands, whether Government on privately-owned, and the need for generating forest-based employment for rural artisans ;

The need for meeting vital requirements of fuelwood, timber, minor forest produce and small timber for the rural and tribal populations primarily through the fragmentation of all denuded and degraded lands, regardless of their classification ;

The need for eliminating the pressure of industry on natural forests ;

The need for encouraging more efficient and restrained use of forest resources by all sectors of society ;

The need for integrating the imperatives of forest conservation into all government programmes and activities which, directly or indirectly, relate to forests ;

The need for sustaining a people's movement for achieving these objectives ;

The need to decentralise control over forests to local communities in a phased manner.

The present policy of 1988 also suffers from the angle of conservation and also in mitigating the needs of the people. The objectives should broadly be as follows :

A rapid increase in forest cover, a key indicator of national well-being, through the protection of all existing forest ecosystems and the creation of tree cover and, where this would be more appropriate, grass cover on all degraded and denuded lands which are not fit for permanent agriculture ; and

Generation of employment for the unemployed and under-employed rural and tribal population, and the derivation of other long-term economic benefits that flow from environemtally well-managed resources.

But forest has a multiple role to play which is :

Conservation of environment : Forests need to be particularly protected on hill slopes, catchments of rivers and lakes, river- and canal-banks, foreshores of water bodies and oceans, in semi-arid and arid tracks, in areas which form the major habitats of the country's flora and fauna and for the maintenance of

water balance and mitigation of climatic fluctuations. Special emphasis should to be placed on the adoption of suitable forestry programmes in all denuded areas.

Production from forests : Consistent with the needs of the environment, all existing forest ecosystems must be adequately protected and not subjected to any non-sustainable exploitation. Over a specified time period, industrial wood production must be totally phased out of forest lands.

Maintaining characteristics and integrity of tribal habitats : Tribal life styles have evolved in harmony with their forest environments. If alienated from such environments or if these are drastically modified, they will require a long time-span for making re-adjustments in their ways of life which often suffer disruption. For retaining the quality of life of such tribal populations, therefore, their natural forest habitats, as well as their traditional rights in forests, must be fully protected.

Conservation of flora and fauna : The conservation of total biological diversity is one of the main aims of the Forest Policy. This requires the careful maintenance of Sanctuaries, National Parks and other protected areas, as well as the early demarcation of Biosphere Reserves, for the conservation of the entire spectrum of biological species in their pristine state.

Recreational values : Selected forest areas should be developed to provide educational and recreational opportunities to the people, specially the young.

Grazing facilities : The provision of fodder for our large livestock population by the establishment and improvement of pastures in selected forest areas as well as in fallow, denuded and marginal agricultural lands is an essential condition for the successful regulation of grazing in forests and the maintenance of pastures. It is necessary to regulate the entry of domestic animals in accordance with the carrying capacity of forest areas. A humane grazing policy must be evolved wherein the interests of forest protection and renewal are harmonized with the livelihood requirements of communities dependent on grazing animals. At the same time, alternate employment opportunities must be provided for those dependent on the grazing of unremunerative cattle and goats.

Minor forest produce (MFP) : The term 'MFP' covers all the forest-based resources which have traditionally sustained

the economy of tribal and other communities and people living in and around forests. It includes a wide range of plants of medicinal and economic importance which need to be saved from over-exploitation by interested parties including some large corporations. Special care should be taken to ensure that tribal people cease to be mere wage labourers and share more fully in the profits of trade and industry based on MFP. In view of the economic importance of the genetic diversity of trees, wild plants and animals for food crops, medicines and fuel in natural forests, the term 'minor forest produce' is a misnomer which suggests that timber is the major produce of forests. MFP should, therefore, be substituted by the more appropriate term 'non-wood forest produce' or 'NWFP'.

The rapid decrease in the area possessing adequate tree cover represents possibly the gravest threat to the well-being of our country and its people. The highest priority must accordingly be given to stopping any further reduction in tree cover both by protecting existing forests from destruction and by providing alternative sources for the essential fuel, fodder and timber needs of the people and the requirements of forest-based industries. This in turn can be done only by establishing forests and pastures on all degraded and denuded lands whether these are classified as forest lands or non-forest lands and which amount to at least 88 million hectares. Such a task will require a necessary reorientation of our development strategy and massive additional investments in the forestry sector.

The notion still widely entertained that forests as such have no intrinsic right to land but may be permitted by sufferance on residual lands not required for any other purposes is born out of ignorance. In consequence there is no proper assessment of social and environmental costs and benefits when vast areas of forest lands are deforested and diverted for such purposes as the construction of dams and reservoirs, rehabilitation of displaced populations, mining, industrial and defence activities, and the expansion of agriculture. In future, all such diversions should take place only after the most careful environmental impact assessment or examination of the matter by suitably qualified authorities. The projects which call for such diversion should automatically include funds as a part of the project cost to provide for compensatory afforestation. Quarrying or

mining in Forest areas invariably results in depletion of tree cover, accelerated soil erosion and pollution of groundwater. Therefore, the beneficiaries enjoying quarrying mining or similar rights should be required to bear the cost of regeneration of the forest areas thus exploited and revegetating them in accordance with accepted forestry practice.

The management of all forests should be strictly regulated to ensure the maintenance of their basic environmental functions. Currently, most of the forests are worked, according to 'Working Plans'. These 'Working Plans' fix the quantum of produce to be extracted from each forest division and lay down all the prescriptions for raising plantations, etc. There is, however, better ecological basis for such 'Working Plans' which require close scientific scrutiny. For example, current scientific opinion considers the tropical evergreen forests as a non-renewable resource, yet intensive commercial exploitation has been carried out in such forests. Modern ecological concepts, therefore, need to be incorporated in what should more appropriately be termed as 'Eco-Management Plans', instead of 'Working Plans'. Integrated and comprehensive forestry, hydrological, soil, botanical, geological, and zoological surveys should be periodically undertaken to form the basis of a regular revision of management policy in state forests. Furthermore, all working should be completely prohibited and strict protection should be provided in forests which clothe ecologically sensitive areas such as steep slopes, sources of major rivers and geologically unstable terrain. Full protection should also be afforded to all areas set aside for the purpose of conservation of biological diversity which would not only include the large national parks, biosphere reserves, wildlife sanctuaries but also similar areas such as preservation plots and those traditionally protected as 'sacred groves', etc. As the richest repository of biological diversity, the remaining tropical rain forests which are now confined to limited areas in Kerala, Arunachal Pradesh and the Andaman & Nicobar Islands require total protection from any further exploitation. All mangrove forests, wherever they occur in the country, should also be totally protected.

During recent decades, many natural forests have been clear-felled and replaced by monocultural plantations of quick growing species usually exotic—by various State Forest Departments and

State Forest Development Corporations. This has led to the loss of much biological diversity and also to certain other ecologically harmful results. It is necessary to ensure that clearfelling is not undertaken under any circumstances and that the choice of species for afforestation is made only after a very careful consideration of all available ecologically and socially suitable species. Non-indigenous species should not be utilised for afforestation without adequate trials regarding their suitability and monocultural plantations should be discontinued. Currently, when monocultural plantations reach their rotation age, they are clearfelled. Since, over the past several years, the areas planted each year have increased substantially vast blocks of plantations extending over hundreds of hectares are thus laid totally bare in single clearfelling operations, exposing such areas to dessication and soil erosion. This practice needs to be stopped and plantations, on reaching maturity, should be felled only in a phased manner with at least a partial canopy left intact. Planting should then be taken up in gaps despite some sapling damage. In the past years, extensive areas of natural forests in the catchments of rivers, around reservoirs, etc., have been clearfelled to raise monocultural plantations. No monocultural plantation has the canopy density to prevent soil erosion or the humus-rich forest floor to retain the rainfall to feed seepage or deep percolation. This is particularly so in hilly regions. For the forests to serve their environmental role, catchment forests must comprise the natural climax vegetation, and the extensive existing plantations must, therefore, be converted to natural mixed forests in a phased manner so that their larger environmental roles are effectively restored.

The wellbeing of forests is a paramount environmental, concern, and not merely an economic issue. On the assumption that plantations of mostly single favoured species are economically more valuable than the natural so-called 'miscellaneous' forests, maximum conversion of natural forests has taken place. Yet there has been no in depth analysis of the economic or ecological viability of such enormous conversions. An independent detailed analysis of the whole policy of conversion of natural forests or raising monoculture plantations in deforested areas needs to be carried out very urgently. Details of site quality changes, runoff rates, actual as against anticipated productivity,

etc., of our plantations must be assessed all over India since an unproven management practice is being carried out on too vast an area of the country. The consequences of even such methods as selection felling in closed canopy forests have not been studied nor their long-term implications assessed, and yet such practice continue to be followed on a very large-scale. For the foreseeable future and certainly until the restoration of tree cover up to the 1952 Forest Policy target has been achieved, all forest working should be oriented primarily towards the protection and improvement of tree cover and of the total forest system.

A major deficiency in our forest management has been the absence of incentives for local populations to preserve and enhance the forest cover. One of the methods to remedy this would be to plough back a substantial proportion of local forest revenues to the local development bodies including village panchayats. Financial incentives will also have to be provided in areas where there is presently little revenue from forests, but where there is large scope for afforestation and conservation programmes. In such tracts, special grants and awards may be given to the local development bodies for good performance. Encouragement must also be given to the formation of Forest Labourers' Cooperatives as well as to forest-based cottage and small-scale industries which benefit the local population.

In involving people in forestry programmes, community and village forestry schemes must play an important role. Historical and anthropological research has uncovered the wide range of traditional conservation systems, including sacred groves and a network of carefully managed village forests, that earlier existed in large parts of the country. Unfortunately, our forest policies have undermined these systems by not involving villagers in the protection and management of forests. Our endeavour now should be to recreate a sense of nurturing for forests among tribal and peasant communities. To this end, the village and community lands including those on foreshores and environs of tanks not required for other productive uses should be taken up for the development of tree crops and fodder resources through community ownership although they may be assigned to individuals or other bodies for afforestation. Such forests, besides providing the community with their material needs like

fuelwood, fodder and small timber, also provide recreation and help in employment generation. They will also lessen pressure on natural forests and lessen conflict between villagers and the Forest Department. Wherever required, degraded reserved forests must also be made available for this purpose. For each village, Village Forest Protection Committees (VFPC's) can be constituted, as has been done with significant success in States like West Bengal. The technical and financial inputs as well as guidance for initiating such programmes should be provided by the Government. The revenue generated through such programmes should be shared with the Village Forest Protection Committees in order to provide an incentive to them.

The land laws need to be suitably amended to make it possible for individuals, cooperatives or corporations to grow tree and perennial fodder and fibre crops on their own lands as well as on Government lands assigned for the exclusive purpose of growing such crops. Wherever available, lands outside reserved forests should be first utilised for this programme. Such programmes can provide enormous employment potential for our vast rural population. Suitable measures should be devised to help the individuals or agencies concerned through loans, subsidies and subsistence allowances, etc., to tide over the long gestation period required for the raising of tree crops. While encouraging the raising of tree crops and pastures on land belonging to individuals, communities or industry, a guarantee should be given that lands which are used for such purposes will not be nationalised merely on the grounds of their being under tree cover or pasture. At the same time, all encouragement should be given for the scientific management of such lands and safeguards provided against their diversion to other purposes.

It is necessary to encourage the planting of trees on road sides, along rivers, canals and railways and on all other unutilised lands under State, Corporate and Institutional ownership. This will not only add to our fuel and forest resources but also provide valuable protection against wind erosion and help in the improvement of the micro-climate.

Though only about 3 million hectares are subject to shifting cultivation, in most areas the negative impact of this practice on the environment is very considerable because population pressures have reduced the 'jhuming' cycle to a very low level.

As a result, agricultural production from 'jhumed' lands is falling and increasing denudation and soil loss are creating serious problems of land degradation. Because of the complex social and cultural overtones involved, shifting cultivation can be controlled only through a cooperative effort motivating local populations through the introduction of alternative programmes. Integrated programmes of agriculture, horticulture, animal husbandry and forestry, suitably harmonised with proper land-use practices, should form the backbone of such a strategy.

Recent experience has shown that excessive pressures have led to a serious depletion of our forest resource base. Hence, it is not feasible any longer to exploit the remaining natural forests to start new or to expand existing forest-based industries. Therefore, there must be a total ban on programmes of clear-felling natural forests to raise industrial plantations, while selection felling from natural forests must also be phased out and stopped within a specified time frame. No forest-based industries, whether in the big or small-scale, should be permitted in the future unless they have been first cleared after a rigorous scrutiny by a Central Agency with special reference to their environmental consequences. Such projects may be permitted only if they are based wholly on new man-made forests grown on degraded and marginal agricultural lands. However, such lands must not he held as captive plantations by industry ; if they are government lands, they can be afforested by landless families under a tree patta scheme, while private lands may be afforested by individual farmers. In the latter case, industry should liaison with private farmers who can supply them the necessary raw material. Government should set up appropriate credit and marketing agencies to help tree farmers.

This new Policy envisages a conservation-oriented forest management requiring the protection and maintenance of forests for their ecological role rather than as a revenue earning source. This shift to protective forestry with the elimination of clearfelling and rethinking on monocultural plantations necessitates a thorough reappraisal of the role of State Forest Development Corporations. The smaller States cannot afford the expensive duplication of infrastructure for forestry operations and greater destructive pressures on the remaining forests, and the corporations in such States should be wound up. The

larger States have enormous unproductive land resources, and their Corporations should be charged with the responsibility of raising mixed plantations in barren areas. In regreening presently barren areas, such schemes can also generate significant employment in rural areas.

Forest-based industries must not continue to be supplied with State Governments with increasingly scarce raw materials *at very low prices*, an arrangement which gives rise to unhealthy practices and over-exploitation. Instead, such industries must be encouraged to obtain their own supplies at market prices which will automatically stimulate plantations of quick growing trees on degraded lands.

These two major sources of damage to forests have to be corrected by combining improved controls with a constructive humanitarian approach designed to provide alternatives wherever possible.

Encroachments : Encroachments in the forest and revenue lands have become a cause for major concern. Such encroachments are generally made either for agricultural purposes or for the construction of hutments, largely by members of the poorest segments of our population. As these encroachments are largely a consequence of inequality of land hording and growing unemployment in rural areas, in the long run they can only be controlled outside the forestry sector, e.g., through land reforms and employment guarantee schemes. However, existing encroachments on the fringes of forests by weaker sections of the population such as tribal people and other local villagers could be best dealt with by using the same population to put the encroached land under tree cover. Social forestry programmes, backed by adequate incentives should be utilised for this purpose.

Protection from fires : The almost universal practice of deliberately firing standing grasses to ensure fresh regrowth has resulted in an extraordinarily high incidence of forest fires in India. Vast stands of timber are damaged and natural regeneration undermined by forest fires. Forest fires can be particularly devastating for young trees, be they of natural or plantation origin and more so if these are pines, eucalyptus, etc. There are well-marked fire seasons in every part of the country and it is necessary to observe extra precautions during these seasons. A modern system of fire watching and organised

fire-fighting needs to be established. Forest policy requires the creation of special expert groups with the principal task of preventing fires and also of applying modern fire-fighting techniques to quickly control them before much damage is done. At the same time, better employment opportunities and the supply of fodder and fuel to neighbouring villages during the summer months will help to reduce fire hazards by discouraging entry into forest areas.

Forestry education : Adequate facilities should be provided for the training of all grades of staff to ensure a high level of professional competence. It is also necessary to encourage specialisation among the staff for better management skills. Periodic in-service training courses are essential to keep the staff well-posted with the latest developments in forestry and wildlife, etc. Special efforts should be made to include, wherever possible, tribals and forest-dwelling peoples who have a special affinity with natural living resources in such programmes. With a view to absorbing them in the mainstream of forest conservation both professionally and non-governmentally. For this purpose, a comprehensive review of the working of the Forest Research Institute and Colleges and other forest training and research institutions is necessary, which should take into account the new priorities spelt out in this revised National Forest Policy. Forestry education also needs to be made part of the general school and college curriculum.

Forestry extension : No conservation programme has any chance of success without the willing support and cooperation of the people. It is essential, therefore, to instil in the people, and in the youth in particular, a direct interest in forests and their development ; and to make them conscious, through the involvement of educational institutions, of the value of trees, wildlife and nature in general. With these ends in view, it is essential that suitable programmes are formulated and implemented through an extension machinery which may be created specially for this purpose. Such programmes must create a stake for villagers and tribals in forest management by devising institutional arrangements which confer authority on local communities to manage forests in their vicinity.

Forestry research : In the last analysis, the creation of a strong forestry sector in India must be based on an adequate

research base, which should take into account the fact that the total non-agricultural area in the country (after excluding urban and other inherently unproductive areas) which needs to be placed under permanent pasture or tree cover is as much as 123 mh as against 143 mh under agriculture. However, the extent to which forestry research has been hitherto neglected is reflected by the fact that while there are nearly 25000 scientists engaged in agricultural research, the corresponding number in the field of forestry is only a few hundred. Although the Forest Research Institute has an established reputation, the research done in it is to a large extent in the hands of deputationists from the forest services who do not stay long enough at their jobs. Forestry research must be entrusted to full-time professional scientists if it is to come up to expectations.

Essential need for specialisation : On account of the scope and diversity of the various problems of forest management, it is essential that Forest Managers should specialise in specific fields such as forest botany, ecology, conservation, genetics and tree breeding, physiology, pathology, and entomology ; wood anatomy ; forest biomass processing and utilisation ; logging ; preparation of working plans ; social forestry ; project planning and implementation ; forestry legislation, etc. This can be done by proper career planning of officers after they have put in enough service in the general line to enable them to decide on which of the subjects they would like to specialise. However, the horizontal entry of specialists in various disciplines into forest departments should also be permitted. The recruitment of such specialists should be through a rigorous procedure. Specialists should normally serve within their own fields throughout their career.

Service conditions : By the very nature of their work, forest staff experience many inconveniences and lack many amenities. In view of this, special efforts need be made to ensure the selection of personnel who will fit suitably in the working environment. To illustrate, special consideration should be given to the recruitment of tribal people at the level of the protection staff. It is also necessary to provide forest personnel with certain minimum amenities in the interest of their morale and high standards of professional competence. Their salaries and other conditions of service should be commensurate with the value

of the service they render to the nation and the arduous duties they perform. Free medical care ; housing and educational facilities for children are some areas needing special attention.

A primary task of all agencies involved in forest management, including Forest Development Corporations, should be to provide employment to local populations in silviculture management, extraction and utilisation of forest produce as well as in forest-based industries. It is necessary to improve the economic status of the labour force, particularly of the tribal people who live in and around forests, by promoting their close involvement in the working of forests. Intermediaries who exploit both the forests and the labour must be substituted by either departmental labour or labour cooperatives. The active participation of local populations and tribal people in social forestry and forest-based industries and trade must be encouraged by all possible means. Programmes should also be undertaken to train tribal people for employment outside the forestry sector in order to relieve the pressure of growing tribal populations on limited forests resources.

It is obvious that the objectives of the new Forest Policy cannot be achieved without the investment of very large sums of money. If areas running into tens of millions of hectares are to be placed under permanent vegetal cover, if the further degradation of the country's basic natural resources is to be halted, and its economy is to be regenerated, then it is necessary that the forestry sector should be allocated adequate budget to transform into an asset which needs to be protected and enhanced to the maximum possible extent so that it may play its optimum role in the well-being of the people. The fullest possible use should be made of institutional finances to support social and community forestry.

The improved accessibility of hitherto remote forest areas has often created problems of over-exploitation and encroachments. The road and communication network (including that for defence purposes) in the remaining natural forest areas of the country should, therefore, be planned with the utmost care. Where the construction of roads is unavoidable, these should be kept to the barest minimum and undertaken only after adequate geological and geomorphological investigations have been

carried out and precautions have been taken to minimise soil erosion and the danger of landslides.

There should be an absolute ban on the export of wood-based forest produce. Clearance for the export of minor forest products should be given only after ensuring that this will not threaten their survival, or the livelihood of forest dependent communities.

Paucity of data is a serious handicap in effectively managing the forest resources of India, which have caused grave ecological errors. No accurate estimate is available of even the total land under forest cover. There is very little data on the composition, dynamics or evolution of many of our ecosystems such as the tropical evergreen forests to decide whether they are naturally replenishing resources. No reliable identification has so far been possible of the remaining intact natural forests. There is also the glaring absence of economic analysis of forests, apart from the productivity of the timber resources, or in terms of a cost-benefit analysis for retaining or totally destroying a forest, taking into consideration the various environmental benefits for which we currently do not attribute monetary value, such as water or top soil. Such inconsistencies and gaps in data regarding forest resources are a matter for grave concern because they help to create a false sense of complacency and prevent the public from knowing the full extent and rate of their depletion. This is a serious matter in which very early steps must be taken to improve the existing methods for the regular collection, collation and publication of reliable data on all the diverse aspects of management of the crucial forest environment of the country. There must be full freedom of information, and all data on forests and forest management must be open and accessible to all members of the public.

3

Ecological Setting

The State of West Bengal covers an area of 88,752 Square kilometres approximately and supports a population of 5,45,80,647 (as per 1981 Census) and the density of population is 615 per square kilometre. The forest area of the State is 11,879 square kilometres, being 13.4% of the total geographical area. The per capita forest area 0.02 hectare is a very low figure in comparison with the All-India per capita forest area of 0.12 hectare. The forest area as percentage to the total geographical area for India stands at 23 per cent approximately.

The land mass of West Bengal is geologically heterogeneous with rocks of different ages, beginning from the Precambrian (1000 million years old) to the recent period. The oldest rocks, the granites and schists of Precambrian age, occur in the western part of the State in the districts of Purulia, Bankura and Midnapore. The greater part of the State consists of a flat or gently undulating alluvium plain with elevations less than 30 metres. The south-western part of the State consists of uplands which are parts of the crystalline rock area extending from Bihar. The northern part of the State consists of a steep hilly rise, being a part of the Himalayan range.

In terms of climatic conditions, soils and physiography, the entire State can be divided into six agro-climatic zones where the types of vegetations vary. The broad classification of these are as follows :

1. Hill Zone—Soil is largely sandy and acidic.
2. Terai Zone—Soil is highly acidic and sandy.
3. Old Alluvium Zone—The Soil is acidic.

4. New Alluvium Zone—The soil is neutral and supports a very intensive and prosperous agriculture.
5. Laterite Zone—The soil is red laterite with honeycomb ferruginous concentration at depths of 15 to 30 centimetre.
6. Coastal Saline Zone—Soil pH plus ranges from 6.5 to 7.5 with electrical conductivity varying from 3.0 to 18.0 millimetre. Drainage is poor.

II

During the period from 1951 to 1976, West Bengal has lost forest areas to the extent of about 3245 square kilometres, as per West Bengal Forest Statistics (1984 : 18) for the following Sectors. Table 3 : 1 depicts details of loss of forest area.

Table 3 : 1

LOSS OF FOREST AREAS

1. River Valley Projects	17	Square Kilometres
2. Agriculture	3137	,, ,,
3. Construction of Roads	26	,, ,,
4. Industries	29	,, ,,
5. Miscellaneous	36	,, ,,
Total	3245	Square Kilometres

Forests of the south-western tract and the mangrove in the Gangetic delta have been recklessly exploited in the past, and the scars of ecological ravages are still writ large. While efforts for extension of treelands under social forestry projects are encouraging, a large population residing in the vicinity of forests are either landless or have no land to spare for tree cultivation. They surreptitiously remove forest produce for domestic consumption and frequently for small gains through illicit trade.

The sustained exploitation of forest resources for the benefit of the present and future generations demand harmonious relationship between man and nature. This is the principle of sustainability which is also the guiding principle for development at

local levels. Unsound technology and unrestrained exploitation for short-term gains are bound to ruin the forests through soil erosion, depletion of fuel resource, loss of genetic diversity and so on.

III

Birbhum, Burdwan, Bankura and Midnapore districts form the Western boundary of the State in the West Bengal Plains Division. The geological formations in Birbhum are Archaen gneiss, the Gondwana system—laterite and Gangetic alluvium. The gneiss, belonging to the division, designated Bengal gneiss, is remarkable for its heterogeneous composition. The coal is found in the Gondwana system in the South-West, North of the Ajoy, which forms the small Tangsuli coalfield on the northern bank of the Mor river at the northern edge of the Raniganj coalfields. The coal is of poor quality, and often no better than a carbonaceous shale. The Birbhum laterite in the middle West was soft in the first exposure but it got hardened and shaped like a honey-comb after exposure to the air for sometime.

Burdwan is covered primarily with alluvium, except for the Asansol subdivision where Gondwana rocks are exposed. Most of the alluvium belongs to the older formation. This is usually composed of massive argillaceous beds of a rather pale reddish brown hue, often weathering yellowish dissemination, through which occur kankar and pisolitic ferruginous concretions. The Gondwana rocks in Asansol subdivision form the major part of the Raniganj coalfield and are divisible into upper and a lower zone.

The greater part of the district of Bankura consists of a rolling country covered by laterite and alluvium. To the east, there is a wide plain of recent alluvium, while gneissose and schistose rocks of Archaen age are found to the extreme West forming the eastern extremity of the immense area of similar rocks in Chota Nagpur. In addition, sedimentary rocks of the Gondwana system, forming the southern part of the Raniganj coalfield, occur in the extreme northern part of this district, between Mejia and the Beharinath hill and contain some useful seams of coal. A number of dolerite dykes cutting across Gondwana rocks as well as the Archaens are found in the north-western parts of the district. The Archaen

rocks are predominantly gneissose, cut across in places by granites, pegmatites and vein quartz. The south-western parts of the district contain mica-schists and phyllites, in continuation of the Iron-ore series of the rocks of Singhbhum and Manbhum. Of great interest are the associated anorthosites in the North. They are monomineralic rocks, being composed almost wholly of the felspar, labradorite.

The characteristic formation of the district of Midnapore is laterite, which occupies nearly the whole country in the North and West, but in the South and East gradually it gives way to alluvium of the Gangetic delta. In the North-West, strongly folded mica schists, phyllites and epodiorites of Archaen age are traceable, these being in continuation of similar rocks exposed in Dhalbhum. Beds of gravels, grits and sand of Tertiary age are found to the South of the area of Archaen rocks, eastwards they are covered with the laterite soil. The Archaen rocks, mainly mica-schists and phyllites of Iron-ore series, overlain by Dalma lava, are exposed near village Sildah (J. L. No. 305, P. S. Binpur —22°37′ : 86°49′) westwards, having a general East-West strike. An important mineral of the district is common salt, which is preferred for local consumption by the villagers along the Midnapore coast obtained by scraping and lixiviation of the saline incrustation of the soil. From time to time, attempts to manufacture salt from sea-water on a commercial scale have also been made without much success on account of comparatively heavy rainfall, relatively high humidity in air, shorter working season and the relatively low salinity of sea-water here.

With the exception of the Goghat Thana, the entire district of Hooghly is alluvial in formation ; the major part of Goghat Thana consists of low laterite fringe of the Bankura uplands or of alluvium mixed with laterite debris.

The district of Howrah is composed of alluvium and it presents no features of special geological interest. The surface soil in the western part of the district, served by the Rupnarayan and the Damodar, is sandy loam, while near the Hooghly, a hard clayey loam predominates.

The district of 24 Parganas is covered with alluvium in great depth. A boring in the Garden Reach area up to a depth of 397 metre has revealed no rocky bottom or marine beds. The surface

soil close to the Hooghly is a hard clayey loam, while in the northernpart of the district sandy loam predominates.

A portion of the district of Murshidabad, East of the Bhagirathi, is covered with recently grown alluvium, consisting of sandy clay and sand along the courses of the rivers. The limit between the alluvium and the higher ground on the West of the Bhagirathi is marked by a bank of stiff clay, gravel and calcareous nodules.

The whole district of Malda is covered with alluvium. The eastern part of the district is occupied by the *Barind*, which belongs to an older alluvial formation.

West Dinajpur district is uninteresting so far as its geological formation is concerned. The whole of it is almost covered with alluvial deposits of recent formation. The soil consists of a clayey silt, ash coloured in appearance which is locally called *Khiyar*.

The Gangetic delta has been divided into three parts. viz., moribund, mature and active. The central object in studying the hydrography of the Gangetic delta has however been necessary to bring out in detail the nature of the distribution of population in different parts of the deltaic region and to ascertain how far it is influenced by the geographical conditions. The elements of physical environment determine the nature of irrigation, land fertility and the salubrity of the area. This physical environment, in the case of the Gangetic delta, is found to be largely composed of, and dominated by, the rivers. Therefore, a study of the character of the rivers provide a key to the ecological conditions of the zone. A part from this physical element, there are also socio-political factors that enter into consideration of the ecology and determine ultimately the nature of distribution of population in its confines and correlation of the physical elements with the distribution of population.

The name 'delta' was first applied to the arcuate, fan-shaped deposit formed by the river Nile at its confluence with the Sea. The shape of the land between the two extreme distributories and the sea, resembled the Greek Capital letter $\triangle$ (delta) and hence was named after it. Subsequently, the study of other rivers elsewhere also showed that a similar phenomenon common to them, and so the term delta came to signify all such formations at the confluence of the rivers with the sea. By the word 'delta' today it is meant that '...a deposit, partly sub-aerid, built by a river into or against a body of standing water'. The districts of

Murshidabad (only the portion east of the Bhagirathi) and 24 Parganas have fallen within this region.

Nature influences the activities of man, rather than directs him, to adjust himself to the environment, to the best of his knowledge and ability. But this influence acts within certain limits and therefore, a still better term would be that of '...human adjustment to the natural environment'. The nature of adjustment finds expression in the geographic pattern displayed by the distribution of population.

IV

Located approximately between 21° N and 27° N in North Eastern India, at the head of the Bay of Bengal with the rampart of the Himalayas only about 480 kilometres from the sea, the climate of West Bengal is marked by uniformities of temperature. The East-West mountain range effectively bars the access of polar air invasions at low levels. The annual range of temperature does not form continental character. The latitudinal range is not large enough to cause marked differences in the pressure and temperature conditions within the State. Climatic differences within the State are due to significant differences in precipitation totals. Both the Himalayas in the North and Chota Nagpur Plateau in the West influence the climate of West Bengal. The monsoon rhythm is the dominating characteristic in West Bengal, as elsewhere in India, and it is only in the onset, duration, date of withdrawal and intensity of rainfall that West Bengal differs from the Upper Gangetic Plain.

Winter surface pressure conditions, dominated by anti-cyclonic air, increase latitudinally. In January, western depressions are rare. They do not have closed circulations and are non-frontal in character. These winter depressions originate in mid-latitudes and play a vital part in the climate of West Bengal.

Summer surface conditions show the dominance of the low pressure over North Western India and a semi-permanent low pressure over adjacent Chota Nagpur. The westerly jet stream at 150 mb. level is displaced to the North of the Himalayan block towards the end of May or early June. In a normal monsoon day between June and September, an elongated trough extends from north-western India to eastern India at the surface level. This

trough does not normally appear over West Bengal. It lies approximately over 20° N in northern Orissa. The trough is constantly fluctuating from North to South and it has been found at times over 25° N (North Bengal).

From June to September, the mid-trophosphere is dominated by a high pressure-point over the Himalayas and the whole of the Tibetan Plateau. North Bengal is situated just below the southern rim of this high pressure zone. Over the rest of West Bengal, there blows a broad easterly current ; this current concentrates into a jet stream with the core in the mean position along 15° N latitude. This jet stream passes towards South of West Bengal. This upper easterly current occurs subject to disturbances and wave-like secondary wind maxima. These wind maxima, in the form of jetlets, are occasionally found over Calcutta and suburbs. These disturbances are of utmost importance in West Bengal climate.

V

Except for the Himalayan region, the climate of West Bengal is tropical. The temperature in the Himalayan district varies from well below freezing point in winter to over 26.7°C in summer. The maximum mean temperature is 8.3°C in Darjeeling, 2137 metres and (23.3°C) in Jalpaiguri, while the minimum mean temperature is 1.7°C and 10°C respectively. The summer temperature in the plains varies from 26.7°C to over 44°C, but the proximity of the sea exerting a sobering effect makes the temperature bearable. Winter is pleasant and cold here, and it stalks between late November and the middle of February. Mean January maxima, minima and absolutes significantly decrease with the increasing latitude. The January isotherms have an East-West alignment. However, large sections of the extreme northern area are sufficiently elevated to experience temperatures well below the normal for the latitudes. Altitude above 3800 metres are snow covered in winter.

May is the hottest month in West Bengal, but April mean maxima are found to be higher in northern part of West Bengal. Highest temperatures are found in the western portions bordering Chota Nagpur. Temperatures decrease both southeast-wards and northeast-wards. The moderating influence of the sea is reflected

in summer months with the westward increase of temperature. Diurnal ranges are uniform—12.0°C in Jalpaiguri and 12.1°C in Midnapore. It is only in the extreme South, in Calcutta, that the diurnal range is 9.0°C. Asansol has both the highest mean maxima of 39.1°C and the largest diurnal range of 12.8°C in May. The mountainous tract has temperate weather conditions. Correlation was found to be significant between the diurnal range in temperature and mean maximum temperature.

Temperatures in the rainy season are more or less uniform in the plains—from 30.8°C at Jalpaiguri to 32.3°C at Calcutta. This uniformity is due to the influence of the south-west monsoon in lowering temperatures which bring an overall uniformity to the climate.

VI

Precipitation is derived from four sources in West Bengal, viz.,:

(1) Winter rain associated with westerly winter depressions and convergences.
(2) Pre-monsoon rainfall (March-May) associated with conventional overturning of air.
(3) Cyclonic disturbance of varying intensity during monsoon and post-monsoon seasons.
(4) Monsoon currents occurring along convergence lines of the monsoon sea level trough.

Mean annual rainfall distribution shows :

(a) Incidence of orographic rainfall in the submountain zone.
(b) Precipitation decreases north-westwards in southern West Bengal. Inclination of July isohyets of West Bengal reflects the south-easterly current of the monsoon winds. The penetration of oceanic influences up the Rupnarayan valley is noticeable. The North-south alignments of nor'wester isohyets reflect increasing totals eastwards.

The average rainfall in the State is about 70″ (175 cms) of which 50″ (125 cms) precipitate from June to September. There are, however, wide regional variations in rainfall. The Himalayan region receives the heaviest rainfall, ranging from 250 centimetres to over 500 centimetres while the districts at plains receive on an

average 125 centimetres to 187.5 centimetres. Among the districts, Bankura has the lowest rainfall 117.5 cms and Jalpaiguri, the highest 390 centimetres. With such wide variations, the State frequently suffers from droughts and floods. Droughts in the State more often mean want of adequate rainfall in time than complete failure of rainfall. Similarly, floods are not always without their compensations, as they flush the land, depositions of silt revive the fertility of the soil.

VII

The forests in West Bengal can be divided into three groups, as follows :

1. North Bengal forests
2. Deltaic/mangrove Sundarban forests
3. Lateritic forest of west part of West Bengal.

In general, some kind of similarity is evident in respect of North Bengal forest with that of the Himalayan forest in the Indian context. This is also true for the lateritic forest in terms of geology and climatic conditions. Deltaic/mangrove forest of the Sundarbans (only one-third is retained in India, while the two-thirds are in Bangladesh) is marked by typical in its nature and manifestation. These three forest zones with peculiar features, are criss-crossed by different kinds of rivers. These zones are quite distinct from others. These distinctive features have importance on the lives of the people and deserve special consideration.

In North Bengal plains forests, the principal rivers are Pana, Jainti, Dima, Rydak and Sankos which flow in zigzag manner. In Darjeeling hills, the principal rivers are Tista, the big and little Rangit, Ramam and Balason, and the small rivers and streams are Sing Pratap Khola, Sirikhola, Lodhama Khola, Rong dong Khola, Lopchu Khola, Pes Lake Khola, Geil Khola, Rombi Khola Pachim Khola and Rongmuk Khola or Jore Khola. These rivers in the hills flow to the South, but West to East ridges across the tract cause a series of rivers and streams to flow northwards or eastwards before joining the main river system.

The Ganges river system separates the northern part of the State from the southern. Other important rivers in the western part run criss-crossing the laterite forests and they are the

Damodar, Rupnarain, Ajoy, Mayurakshi, Panchet, Kangsabati, etc., which have branched off the Ganges. The Sundarbans consist of the coastal forest belt of the Bay of Bengal on the southern most fringe of the pre-partitioned State of Bengal. It forms part of the Ganges Delta lying between the Hooghly on the West and the Padma-Meghna on the East. The delta is believed to have been built primarily by the deposition of silt, carried down by the Ganga and Brahmaputra river systems. This process of delta formation has been partly assisted by the silt brought down with the tides from the sea-face. The water of the rivers in the eastern part is less saline than that of the western part, because of partial mixing up of sweet water in the rivers of the eastern part of Sundarbans.

VIII

North Bengal is endowed with a rich diversity in vegetational complex, but factors that interfere with natural distribution of vegetation are mainly as follows :

(i) Exploitation of economically important plants started more than a century back,
(ii) Shorea robusta forests had their origin and distribution in fire protection,
(iii) Strict fire protection measures rendered the soil moist, making it vulnerable to invasion of evergreen species in the Shorea forests,
(iv) Many fire tender species suffered from surface fire,
(v) Man-made forests replaced the original natural forests over large areas,
(vi) Grazing, lopping, flood and fire had tremendous denuding effect on the forests.

The biotic and climatic factors that each of the study zones has suffered should be independently evaluated.

Although pure Shorea robusta forests form the bulk of the plains forests, maximum diversity is noticed in the wet-mixed forests (dry-mixed types are very local). In the typical dry-mixed forests, both specific and generic diversities are high. One significant indication is that in mixed forests the species have more chances of survival than in the pure forests. In pure Shorea forest the absence of regeneration, fungal disease in wet Shorea forests,

poor coppicing power, etc., present bleak future, unless this species is artificially raised over extensive areas. But the mixed forests have maximum wildlife population. Most of the trees in the mixed forests are fruit-bearing trees. The ground vegetation in the dry-mixed forest is not as rich as those of wet-mixed forests. Gregarious occurrence of a few grasses are significant for browsing of the wildlife population. An analysis of ground vegetation showed that Shorea forests (along with scattered Shorea, pure Shorea and wet-mixed) have 112 species against 72 in Riverine Forests, 72 in dry-mixed forest and 55 in plantations (man-made forests).

Monoculture in the man-made forests is detrimental to wildlife species as seen in the less diversity of species.

Baman Pokri, Khairbani and Chamta reserves show maximum diversity of species and genera. These are typical forest hills. Shorea areas are much disturbed owing to biotic interference. These zones with big patches of dry-mixed forests are ideal habitats for wildlife. Maximum number of bird species, both arboreal and ground and interlayer, and animal species, especially deer, bison and elephant herd are noticed in such forests. But these forests are gradually being converted and replaced by valuable timber species in pure formations.

What is special, of the Kalimpong hill tree vegetation is the strong diversity of vegetation from the foot hills up to 1800 metres. This is not so in the Darjeeling hills where the diversity is maximum at 1000 metres, indicating richness of vegetation (tree) in the foot hills. In these zones again there are abundance of arboreal avifauna and animal species.

GENERIC AND SPECIFIC ABUNDANCE

(a) Genera : Among the dicots, there are 28 families with only one genus, 25 families with two genera, 11 families with three, 10 families with four, 16 families with five and 15 families with eight genera.

Among the monocots, 7 families have one genera.

(b) Species : Among the dicots, there are 26 families with one genus, 15 families with two genera and 12 families with four genera.

Among the monocots, 3 families have one genus.

Only 12 families have good number of generic abundance among the dicots (5 families among the monocots) ; 19 families have sizeable number of specific abundance among the dicots (8 families among the monocots).

A critical observation on the generic and specific abundance and count of individuals shows that about 50% of the angiospermous families have either one or two genera and a few species are among them which are gregarious. This presents a rather gloomy picture of the future, in spite of high diversity in the wet-mixed forest.

(c) Classification of herbs, shrubs, trees and canopy classes :

(i) A synthetic analysis of vegetation shows that 50% of the entire Dicotyledons and Monocotyledons is herb ; 23% of the herbs (1251 species) is in the plains. There are 540 tree species and 628 species of shrubs, most of the species of the latter are found in the plains ; large climbers have 111 and climbing shrubs have 105 species. Furthermore, 205 species of ferns, 11 species of Gymnosperm and about 300 species of Lichens and mosses make the study extremely interesting for diversity study of plants and animals.

(ii) Shorea robusta forests form about 50.0%, 25.0%, 6.0% and 3.0% of the species in pure Shorea, scattered Shorea, wet-mixed and dry-mixed types of forests respectively ; Lauraceous species form about 10.0%, 13.0%, 25.0% and 13.0% of the species in the aforesaid four types of forests respectively ; Meliaceous species form about 3.0%, 12.0%, 20.0% and 14.0% of the species in the aforesaid four types of forests respectively.

(iii) Canopy analysis of the tree species of the aforesaid four types of forests shows that Top storey, Middle storey and Lower storey have about 26.0%, 50.0% and 24.0% of the tree species ; in this canopy classification wet-mixed, dry-mixed, scattered Shorea and pure Shorea forests represent 132, 114, 102 and 77 numbers of species respectively.

These data indicate that herb vegetation in the hills, shrub in the plains and middle storey species have high diversity of species and that the wet-mixed forest is the most important type of forests from the point of view of species diversity. Such areas invariably form most suitable environment for wildlife species.

It was not possible to count the individuals in ground vegetation because of the large number of species.

The specific and generic diversity at different altitudes were calculated by a special mathematical method and are as follows :

Table 3 : 2

REGIONWISE DIVERSITY

Region	*Altitude*	*Specific diversity*	*Generic diversity*
Lower hills	Upto 1000 metres	29.82	141.34
Middle hills	between 1001 to 1950 metres	58.42	288.82
Upper hills	between 1951 to 2920 metres	51.07	266.02

Here again, middle-hills zone, i.e., from 1001 metres to 1950 metres, shows maximum diversity in ground vegetation. Taking the hill forests as a whole, the zone of vegetation from plains up to 1950 metres is considered to be very much viable.

As such, foothill tree vegetation and lower and middle hill ground vegetation together with ground vegetation of the upper hills form the most important biologically viable zone. As compared to adjoining geographical areas the vegetation of this zone is luxuriant. Diversity amongst monocotyledons and pteridophytes is significantly high.

Now computing the generic diversity

Generic diversity $=\frac{S(1-x)}{x}$ where S is the number of species and x is the value obtained for each of the different combinations of S/G where from generic diversities were calculated G is the genus.

Survey of Dicotyledons in undivided Assam (including Sylhet, Meghalaya, Arunachal, Mizoram, Nagaland and Manipur) having more than 10 times the area of North Bengal shows the occurrence of 820 genera and 2355 species, against 774 and 1920 respectively of North Bengal. It is extremely significant that the study area including Sikkim which has about 4000 species of plants is one of the richest and most interesting floral and faunal zone of the world. The abundance of avifauna (about 600 species), mammals

(about 90 species), fish (about 125 species) innumerable species of butterflies, etc., is definitely due to wide diversity of vegetation.

CORRELATION BETWEEN GENERIC AND SPECIFIC DIVERSITY

Computations show that in a ecosystem the generic diversity maintains a positive correlation with the specific diversity. In the present study high generic diversity has been found to be associated with high specific diversity value. The study of specific diversity is of prime importance for evaluation of a particular community or ecosystem. A low specific diversity gives a warning signal for existence of a species which may be due to biotic factor, environmental pollution, lack of regeneration and reproductive capacity, overexploitation, etc.

There are many families with monotypic genus and very few scattered individuals. Many medicinal plants, decorative plants, economically important plants have become rare owing to overexploitation.

(a) *Generic diversity in Dicotyledon families* :

The following families have very high generic diversity (figures in bracket) :

Menispermaceae (11.59), *Sterculiaceae* (10.73), *Meliaceae* (12.94), *Sapindaceae* (10.06), *Anacardiaceae* (15.28), *Leguminosae* (27.00), *Cucurbitaceae* (22.61), *Compositae* (28.89), *Apocynaceae* (23.05), *Asclepiadaceae* (21.75), *Scrophulariaceae* (16.74), *Acanthaceae* (30.29), *Labiatae* (25.67), *Euphorbiaceae* (18.17).

(b) *Generic diversity in Monocotyledon families* :

The following families have very high diversity (figures in bracket) :

Orchidaceae (34.12), *Liliaceae* (18.00), *Palmae* (10.04), *Araceae* (13.33), *Gramineae* (81.01).

(c) *Diversity and faunal abundance* :

Most of the families having high diversity are fruit bearing and also fodder yielding and obviously attract many species of frugivorous birds (*Hill mynah*, *Hornbills*, *Barbets*, *Parakeets*, *Pigeon*, etc.) and graminivorous animals (*Bison*, *Rhinoceros*, *Pigs*, *Thar*, *Serow*, various deer, *Sambar*, *Nilgai*, *Wild Buffalo*, etc.)

In the foothills and adjacent areas there is heavier concentration of birds and animals, including squirrels, civets, mongooses, weasels, martins, monkeys, etc.

Observations in the foothill regions (200 to 1400 metres) show that maximum concentration of bird (Babblers 92%, Laughing thrushes 82%, Warblers 52%, Red start 37%, Wood peckers 100% and similar percentage of Hornbills, King fishers, Fairy blue bird, Mynas, and lesser percentage of Barbets, Minivets, Cuckoo shrikes, Bulbuls, Nuthathes, Sunbirds, etc.) and 80% of animal species (big and small) occurs in this region and in wet-mixed forests.

But diversity alone cannot be responsible for abundance of animal. Higher productivity (in dry weight) has been found to have correlation with animal species diversity. High productivity is derived from Stem, Leaves, Flowers and Fruits. But caloric concentration which is of prime importance for animal species may or may not be consistent with high productivity. Caloric production is more directly involved in animal nutrition rather than in dry-weight production. Pure crop forests and plantations of few species have poor diversity due to poor productivity. Since animals depend on leaves and fruits, more the leaf production, the more is the expectation of animals.

IX

Sundarbans is perhaps a unique example . The wild denizens and particularly the tiger are able to choose the habitat having the least generic diversity of vegetation possibly for extraneous natural factors.

According to Williams C.B. (1964) the low generic and species diversity indicate the high probability of extinction of the living organisms of the genera and species of the complex. This situation warrants a warning signal to guard against future ecological disasters. Low diversity of vegetation of the laterite forests of South Bengal also warrants special treatment.

Linear transect lines were laid out in different parts of forests and the area laid out in the transects were studied to classify the vegetation. Plots were selected by the application of systematic random sampling and were analysed for the study.

The method of determining the relative abundance of plant-animal dynamics is to calculate the generic and specific diversity (Williams, 1964). While determining the specific diversity, samples

were taken by units from a population arranged in a log-series distribution.

Let N be the number of individuals of a species and S be the number of species in a genus. Then X is computed from the formula

$$\frac{N}{S} = \frac{X}{(1-x)(-\log_e 1-x)}$$

Then, specific diversity : $\frac{N(1-x)}{x}$

The generic diversity is determined in the same lines as species diversity. So the generic diversity is computed as follows :

Generic diversity : $\frac{S(1-x)}{x}$

X is determined from the formula where

$$\frac{S}{G} = \frac{X}{(1-x)(-\log_e 1-x)}$$

CALCULATION OF GENERIC AND SPECIFIC DIVERSITY FOR VEGETATION DYNAMICS

The generic and specific diversity for the dynamics of vegetation of Sundarbans mangroves and the results are reproduced in the Table 3 : 3.

Table 3 : 3

DISTRIBUTION OF GENERA SPECIES AND NUMBER OF STEMS PER 0.4 HECTARE IN LAID-OUT PLOTS FOR COMPUTATION OF DIVERSITY (GENERIC AND SPECIFIC)

Tide level	*Number of Genera (G)*	*Number of Species*	*Number of individuals (N) per 0.4 hectare (or acre)*
A. Above General tide level	7	9	3000
B. Frequently inundated	5	7	500
C. Below tide level	10	13	2000

So, both generic and specific diversities were very low in respect of all major fauna of Sundarbans swamp forests.

'X' is computed by the formula :

$$\frac{S}{N}=\frac{(1-x)}{x}\ x-\log_e \overline{1-x} \text{ and}$$

then the index is calculated according to the above formula. This index of diversity is low when the diversity is low and high when the diversity is high. This index reflects the diversity of environment.

It can be concluded from the Table that at zone C both the generic and specific diversity are the highest amongst the three zones, but the generic diversity of the zone A (which is above the tide level) is more than that of zone B (which is frequently inundated) while the reverse relationship exists between the zones A and B so far as specific diversity is concerned. But according to timber and fuel resources zone A is richer than zone B which in turn is richer than zone C. So the richness of resources is inversely related to the generic and specific diversity of the vegetation. Again, it may be seen that the zone C which records the highest generic and specific diversity amongst the three zones does not form an ideal abode of tigers as the tiger possibly avoids the constant tidal fluctuations and hence the increased salinity. Salinity indexes are the most in zone C followed by zone B and then by zone A. A unique example of a very dense but closed vegetational matrix is evidenced from the low figures of both generic and specific diversity. With such low diversity, both generic and specific, Sundarbans inhabit perhaps one of the densest vegetation cover in the whole of the world and is in need of special protection. It is held by naturalists and ecologists that, other factors remaining constant, low generic and specific diversities point to high probability of extinction of the vegetational complex of the region. (Williams : 1964).

Generic diversity was computed for fishes of North Bengal and Sundarbans waters. Similarly the generic diversity was also computed for the laterite tracts of South Bengal in the same method of stratified random sampling and 20 random plots were selected at random from the total number of plots each of size 0.4 hectares and the results were tabulated both for tree vegetation and for shrubs and herbs.

X

Records of 5th and 6th century A.D., when Tamralipta was the port, show the laterite tract as quite important both historically and geographically. It had to be crossed to get access into Varanasi, Gaya, Rajgir and other places. Telkupi, near Panchet, mentioned in the edict of Asoka, was an important place where travellers crossed the Damodar river for journey to Tamralipta. The country was described as 'very full of wild jungles and wild men called the Savaras' (which probably includes Kole, Munda, Santal and Bhumij). The Savaras can be traced as far back as in the Aitareya Brahmana, along with other aboriginal tribes who had spread over the country from the Ganga to Godavari. Their descendents may be identified with the nomadic Savara of the present-day and the Lodhas, as a tribe of hunters, as their name implies (being the corruption of the Sanskrit tag 'Lubdhaka' or hunters). The forests in this lateritic tract were extensive even during the Mughal period, in spite of constant warfares with the Pathans during the greater part of the sixteenth century. It is in this tract Bhaskara Pandit, the Maratha General, lost his way in wilderness after his defeat and wandered away to Panchet, during the middle of eighteenth century, from where he came to the open areas of Midnapore with the help of guides. Under the British rule biotic interference and unplanned exploitation has gone unchecked. This has brought misery to the forests and to its dwellers.

The entire territory is either hilly or undulating, and it forms the boundary line of the last reaches of the older formations of the Peninsula with the Indo-Gangetic alluvial zone. On the Chota Nagpur border, the higher ones rise up to about 600 metres (Ajodhya hills) and the land gradually slopes out to the East, where the laterite belt of earth covers the tract before it merges into the alluvial plains of Bengal. Of the hills, the more prominent ones are Susunia and Beharinath in Bankura, Panchet, Kalma and Ajodhya in Purulia and an off-shoot of Dolma hills from Singhbhum into Midnapore and Purulia districts. The forests are located in the lateritic belt through which run the principal rivers, Brahmani, Mayurakshi, Ajoy, Damodar, Dwarakeswar and Kangsabati, roughly from West to East, into the Hooghly, while the Subarnarekha, the southernmost river, flow independently

into the Bay of Bengal. Denudation and erosion of soil is rampant here. Heavy siltation jeopardise the life of the dams and canals at a much faster rate than anticipated. Because of the dry climate and poor soil, trees have a stunted growth. There is excessive run-off soil due to bare and sloping lands, with consequent erosion from grazing and annual fires aggravating the clean forest floor. The annual fires spread with incredible speed because of highly inflammable and dry conditions of summer months. In this tract, major faunal species are conspicuous by their absence as a result of biotic interference and the annual ritual of tribal hunt menace, with hundreds of people combing out these forests. Only some hares and kinds of avifauna are to be found fighting for their survival.

With repeated cutting of *Shorea robusta* (Sal), much of these laterite forests have given way to *Diospyros melanoxilon* (Kend) and *Madhuca latifolia* (Mahua). In the first stage of retrogression, Sal was also replaced by *Lagerstroemia spp* (Sidha) and at places *Parashi* (cleistanthus collinus) which in turn gives way to Kend *Butea monosperma* (Palas) is also associated with this stage of retrogression. *Soymida febrifuga* (Rahara) is associated with heavy clay soil, usually characterised by the calcareous nodules. Parashi (*cleisthanthus collinus*) is associated with a rather dry type of soil usually the rocky areas, but *Butea monosperma* (Palas) and *Diospyros melanoxilon* (Kend) are rather cosmopolitan in their matter of habitat. Before the last stage of disappearance of vegetal cover, *Combretun decandrum*, *Streblus asper*, and lately *Lantana camara* are often found to rule the roost.

In the South, i.e., the western part of the State including the districts of Bankura, Purulia, Midnapore, Birbhum and Burdwan, there are large tracts of degraded forests termed as laterite forests. These forests were all privately owned in the past and were vested to the State after promulgation of the West Bengal Estates Acquisition Act of 1953. These forests could not, however, be brought into a productive State, even after the State took over, due to repeated maltreatment by the villagers. These laterite forests conform to the forest type called 'Dry Deciduous Forests'. *Shorea robusta* (Sal) is of coppice origin and is the principal species. Other species include *Pterocarpus marsupium*, *Diospyros melanoxylon*, *Madhuca longifolia var latifolia*, *Terminalia alata*, *Terminalia belerica*, *Terminalia arjuna*,

Butea monosperma, etc. Here, the typical soil is termed 'lateritic' or 'Red earth', as the people would call it, and it is the characteristic of the entire tract. Laterite rocks associated with this type of soil are vesicular or nodular, and is commonly found everywhere. Thickness of the laterite varies from place to place and is not known to exist beyond 15 metres in depth in this area. The water-holding capacity of the soil increases with the increase of depth. The soluble salt content and the percentage of carbon and nitrogen are rather low, decreasing further with depth. The carbon-nitrogen (C/N) ratios are rather narrow in the sub-soil samples. Silicon dioxide (SiO_2) varies from 35% to 42%, Ferrous oxide (Fe_2O_3) varies from 4.5% to 12% and Aluminium dioxide (Al_2O_3) varies from 27% to 39%, Calcium oxide (CaO) varies from nil to traces. A massive afforestation drive in this tract brings about not only an effective change in the landscape but also proved effective against soil erosion and brought out an effective imporvement in the rural economy of the tract and the people. An analysis of the vegetation matrix of this laterite tract indicates the presence of 51 genera and 63 species for tree vegetation and 50 genera and 60 species in shrubs, herbs and weeds in this area. So far as diversity is concerned, laterite forests stand between North Bengal Forests and Sundarbans. While the diversity value of vegetation complex for laterite tract is more than that of Sundarbans, it is less than that of North Bengal Forests.

XI

A comparative picture of generic and specific diversity has emerged for three different types of forests of this State—North Bengal Forests, Deltaic/Mangrove Sundarban Forests and Laterite Forests. This has brought out an insight into the relative abundance and other ecological traits of plant-animal dynamics of three different forest types as stated above. Generic diversity of tree vegetation of Sundarban mangroves was observed to be lower than that of North Bengal and South Bengal laterite tracts. Again, the generic diversity of Sundarbans molluscs is found to be more than that of tree vegetation, crustaceans, fish and other kinds of faunal organisms.

The low plant-animal diversity value for Sundarbans swamps is a warning signal for impending hazards if strict protection of this biotope is not ensured. This ecological exercise will come to be of considerable help to reconsider and reorient the broad conservation strategies of the forests of West Bengal, in general. The number of individuals within a species and number of species within a genus remain in a state of natural balance in the midst of complexities of various interactions. The individual species have to struggle for survival against the physical properties of environment and soil and water conditions as also in the competition for food gathering and against the danger of being eaten. This competition is endlessly fought by all species of living creatures in their neighbourhood, and at times even with individuals of their own species.

Sundarban mangroves inhabit higher caloric concentration and significantly high bio-mass productivity with low generic and specific diversity, generally for both flora and fauna. Because of the locational advantages of mangroves of Indian Sundarbans, the degree of biotic interference is less in Sundarbans as compared, to other forest types of West Bengal. Because of this the poor floral and faunal diversity in Sundarbans mangroves is not confronted with the immediate threat of extinction. So, with proper balance in forest management Sundarbans should be able to hold its potentiality in natural ecosystem.

The ecological study will considerably help us to reconsider and reorient the conservation policy of the West Bengal Forests in general and Sundarban-mangroves in particular.

Higher productivity has been found positively correlated with fauna-flora diversity and this higher productivity is derived from stem, leaves, flowers and fruits or, in other words, total bio-mass. But caloric concentration does not bear such positive correlation with either productivity or diversity.

XII

Old stone age implements of various types have been unearthed from different parts of West Bengal, Orissa and Bihar. These were found in large number mainly in West Midnapore, Purulia, Bankura of West Bengal, Mayurbhanj in Orissa and Singhbhum in Bihar, especially in jungle-covered lateritic rugged terrain.

Indication is clear that the earliest form of human civilisation was in and around forest. Besides, a good number of coalfields are also present in some zones where vegetations have turned into coal. However, all taken together, it signifies that vegetation as well as human habitation have existed together as almost part of a system. But, fossil remains of any animal were not found. A vexed question, however, persists whether early men and their descendants, either mixed up with newer groups of people or were totally annihilated. It is said that Protoaustratoid group of people, who constitute the present-day Austric speaking groups, are dominating the tribal groups, like the Santal, Munda, Bhumij, Kora, etc., are concentrated in West Midnapore lateritic zones where forests are present. Owing to certain compulsions, people from different areas came and slowly mixed with them. Heterogenous people of different features and traditions are found to exist together. But in deltaic West Bengal, covered with Sundarbans Saline Forest, people have migrated from different places. Of these people some tribals from Chota Nagpur, such as the Bhumij, Munda, Oraons, constitute the dominant group. They are interspersed with other lower Scheduled Caste people, clinging to the forest and the riverain economy. Again, in the Northern Bengal, in Terai and other jungle areas, some migrant Mongoloid groups, like the Nepalese, are there because of their employment in plantations. This is also true of labourers from Chota Nagpur. All over the forested region, a mixed kind of population with the tribal groups as dominant feature is noticed. They mainly live on forest and forest produces in order to eke out their existence.

4

The Forest Resources

Foothill forests, rich in tree-flora, correspond with the highest concentration of arboreal avi-fauna, animals and terrestrial fauna. A preliminary study of avi-fauna, the only macro-faunal group, with a large number of individuals in this zone, shows close correlation with richness in diversity. Generic and specific diversity were highest in the ground vegetation of the temperate ecosystem.

Survival of *Rhinoceros unicornis*, *Panthera tigris*, *Bibos gaurus*, *Bubalus babalis*, *Cycas pectinata*, *Gnetum scandens*, *Podocarpus neriifolia*, etc., in the highest diversity regions depends on the protection of the ecosystem from biotic depredations.

In respect of synthetic analysis of vegetation, Chaudhuri (1969) had classified the *Sal* or *Shorea robusta* forests of North Bengal into four major groups, viz., Pure Shorea, Scattered Shorea, West-mixed and Dry-mixed.

Linear transect lines were laid out in different parts of the forests. These and the quadrats laid out in the transects were studied to classify the vegetation. Random plots were also analysed for the study. In the case of tree vegetation, 20 plots of 0.4 hectares were surveyed in each type. In the hills, however, 20 plots of 0.4 hectares were surveyed at each altitudinal zone. For ground flora, 20 plots of 4×4 metres were surveyed in each altitudinal zone.

While determining the specific diversity, samples were picked up by units from a population arranged in a log-series of distribution. In all random samplings of any size from one population, the ratio of n_1 ; the number of groups with one unit to X (a number less than unity) or specific diversity is equal to $\frac{n_1}{x}$, according to Williams, C.B. (1964).

The ratio of the number of individuals (N) to the number of species (S) is given by :

$$\frac{N}{S}=\frac{X}{(1-x)(-\log_e 1-x)}$$

The value of X having been found out, the specific diversity is determined as follows :

$$\text{Specific diversity}=\frac{N\,(1-x)}{X}$$

The generic diversity is determined on the same lines as in specific diversity, with the number of species (S), replacing the number of individuals (N) and the number of genera (G) replacing the number of species (S) in the aforesaid formula for specific diversity.

If in a community the species are spread over a large number of genera, the generic diversity is both high and low, if only a few genera are represented.

The generic coefficient is given by the following formula :

$$\text{Generic coefficient}=100\times\frac{\text{Total number of genera}}{\text{Total number of species}}$$

In the case of log series distribution, which many genera and species distributions follow, the relation between the average number of species (S) per genus (G) in a sample form population with diversity (d) is given by :

$$\frac{S}{G}=\frac{e^{\frac{G}{d}}-1}{\frac{G}{d}}$$

Hence the coefficient is $100\times\frac{\frac{G}{d}}{e^{\frac{G}{d}}-1}$

In other words, it is dependent on the ratio between the number of genera represented in the sample (i.e., on the size of sample) and the richness of population. If d remains constant, i.e., if a series of random samples are taken with the same number of genera from two different communities, the coefficient is simply a measure of diversity.

A classification of ground flora, based on statistical analysis, show that Sal forests, Riverain forests, Dry-mixed forests and Plantations have 112, 72, 72 and 55 significant species respectively. Grasses, shrubs and herbs form a small percentage of ground flora in plantations. Plantations of a selected few species are, therefore, not rich in diversity and not suitable as habitats for the wildlife.

That the vegetational diversity-increase goes together with the increase in animal-population is noticed as a matter of tremendous biological and economic importance. A very low generic and specific diversity warrants the necessity of adopting special measures for protection of the floral zones ; Several rare species threatened with extinction may be given protection.

II

Study of plant communities is based on area, rather than on individual, as is the case with the faunal community.

Thus, in floral ecology the use of 'quadrats' or small samples of specified area, often a square metre or less, has gained much importance and has become a standard method of statistical ecology. The 'quadrat' is so selected that it becomes a random sampling of the ecological community under investigation. It is important to see that in order to conform to the necessary requirements of a statistically reliable sample, the 'quadrat' contains a considerable number of units. The aspect of species and generic diversity, adaptation, niche segregation and other ecological dynamics of flora and flora were dwelt by S. C. Kendeigh (1980).

Floristic compositions of tree vegetation in plains are as follows :

1. BELT TRANSECT LINES :

(i) *Wet-mixed forests* :

Altogether, 20 plots of 0.4 hectare each were surveyed at each place and the data thus collected were tabulated, giving the number of individuals and species with their species percentage and density percentage per 0.4 hectare.

Generic and specific diversities were calculated for the following areas as follows :

(ii) *Lataguri* :

Here also, 20 plots of the size of 0.4 hectare each were randomly selected from each of the 3 types of forests, i.e., (i) Wet-mixed forests, (ii) Scattered shorea forests and (iii) Pure shorea forests. The idea was to determine the generic diversity, specific diversity and Jaccard's generic coefficient.

The specific diversity (d) was determined, assuming that the samples by units were taken from a population arranged in a log-series distribution. In all random samples of varied sizes from one population to the ratio of n_1, the number of groups with one unit to x (a number less than unity) or, $d=n_1/x$.

The ratio of the number of individuals (N) to the number of species (S) is given by :

$$\frac{N}{S}=\frac{x}{(1-x)(-\log_e 1-x)}$$

Then x is determined from the above equation by its solution. The specific diversity is determined as follows :

$$d=\frac{N(1-x)}{x}$$

The generic diversity was determined in the same lines as in specific diversity, with the number of species (S) replacing N (the number of individuals) and the number of genera (G) replacing S (the number of species) in the above formula for specific diversity.

If in a community the species are spread over a large number of genera, the generic diversity is high, if only a few genera are represented, the diversity is low.

Jaccard defined his 'generic coefficient' as follows :

$$100\times\frac{\text{Total number of genera}}{\text{Total number of species}}$$

Many genera species seem to follow log-series distribution. The relation between the average number of species (S) per genus (G) in a sample from a population with diversity (d) is given by :

$$\frac{S}{G}=\frac{e^{\frac{G}{d}}-1}{\frac{G}{d}}$$

Hence Jaccard's coefficient is :

$$100 \times \frac{\frac{G}{d}}{e^{\frac{G}{d}} - 1}$$

In other words, it is dependent on the ratio between the number of genera represented in the sample (that is to say, on the size of the sample) and the richness of the population. If d remains constant, i.e., if a series of random samples are taken from the same community of population, the coefficient increases with the sample size. If samples are taken with the same number of genera from two different communities, the coefficient is simply a measure of diversity.

III

FLORISTIC COMPOSITION OF VEGETATION IN HILLS :

(1) *Shorea forests in Terai and foothills* :

Belt transect lines and plots chosen at random were laid out and the data thus collected were analysed. A total area of 800 hectares, each sample plot having 200 hectares, was studied. Each plot had (i) Chamta, (ii) Singimari, (iii) Bamanpokri and (iv) Punding, Koklong and Jogijhora.

IV

A rich heritage of medicinal plants in West Bengal is available in deep forests and some plants growing in rather open wild situations. A few of them are regularly collected as articles of trade, while others are used locally as indigenous drugs. Those that are collected and traded are *Rauwolfia serpentina*, *Piper longum*, *Terminalia belerica*, *T. chebula*, *Embelia ribes*, *Emblica officinalis* and *Asparagus racemosus*. *Luvunga scandens*, *Scindapsus officinalis*, *Argyreia speciosa*, *Croton tiglium*, *Curculigo orchioides* are other drugs which are also collected and taken out of their homeland for use in Kaviraji treatment. *Dioscorea prazerii*, the source of sapogenin, so important in the manufacture of Cortesone has wild growth in these forests. May be, this will have great demand in future for the above purpose. *Solanum khasianum*, and its variety of chatterjeeanum, are also equally important

and useful in the same way. *Adathoda vasica*, *Azadirachta indica*, *Holarrhena antidysenterica*, *Centella asiatica*, *Celastrus*, *paniculatus*, *Mallotus philippinensis*, *Paederia foetida*, *Vitex negundo* and *Wedelia calendulacea* are regularly in use by the local people.

Chatterjee, Ashima (1953) had edited a book entitled, 'Bharater Basundhara' in Bengali which was frequently consulted on the aspect of medicinal plants resources of West Bengal. Shah, N. C. (1978) had dwelt on ethnobotany in relation to medicinal plants as well.

Aegle marmelos is a well-known fruit-tree which is reputed also for possessing medicinal properties in its fruits and bark. This is usually planted and occasionally found self-growing. *Acacia catechu*, a component of the riverain forests, is also an important medicinal plant which is exploited for catechu. *Ricinus communis* is cultivated here on a small scale. Cannabis sativa is famous for its narcotic property. It grows wildly as a weed in this area. Andrographis paniculata, considered to be one of the best cholagogues, also has wildly grown all over the region. The betel vine is cultivated near villages for the leaves which are favourite masticatory objects and are used variously in Kaviraji medicines. Extensively grown Areca nut has also its medicinal uses. *Ocimum sanctum*, grown in every Hindu-house as a sacred plant, is reputed for its medicinal properties. It is also found as a weed along rural roads. Euphorbia nerifolia grown as a sacred plant has medicinal property. *Zingiber officinalis*, which is cultivated on a large scale on hilly regions, is sparingly cultivated in the plains. As there is good demand for ginger in and outside India, cultivation of the same has been intensified. *Costus speciosus* grows wildly and rhizomes are collected regularly for being used by the local people as an antidote for cough. Limes are well-known for their vitaminous contents and these are cultivated as garden-crop.

It is often noticed that useful medicinal plants in good demand are collected injudiciously throwing them to the peril of extinction in certain areas. Such plants require pronation of greater cultivation and protection under the State control. The medicinal plants in the Duars that fall under this category are Rauwolfia serpentina, *Piper longum*, *Asparagus racemosus*, *Embelia ribes* and

Scindapsus officinalis. The value of R. Serpentina is too well-known to need introduction to which care and attention should be given for protection and cultivation. *Piper longum* was fairly abundant in the eastern parts of this area some 20 years ago, but it is not so now. It is necessary to take steps so that this plant does not disappear from this region altogether. The tuberous roots of *Asparagus racemosus* are in great demand by the Indian apothecaries, but their quantity of supply is not sufficient. Cultivation of this root in open forests, especially in Savannahs, is likely to be economically profitable. *Curcuma Zedoaria*, the shati-plant, the rhizome of which is a vermifuge and diuretic, is in great demand as a baby-food. This can grow under tall trees and can be cultivated as a minor forest product and if available in large quantity in the market, it may supplement our starch food to some extent.

V

Honey was one of man's first foods and the first available sweet. It was, and has been, highly valued by the Indians from time immemorial. It has been defined as : 'An aromatic, viscid sweet material derived from the nectars of plants through the collection of honeybees and modified and stored by them as a denser liquid'.

Chakrabarti, Kalyan and Chaudhuri, A. B. discuss various aspects of honey production and the behaviour pattern of the honeybees in the estuarine tracts of the Sundarbans. It covers the aspects of (i) annual honey and wax production and corresponding number of the permit holders and their casualties from man-eaters ; (ii) the size and pattern of the honeycombs and the corresponding honey production ; (iii) honey production relating to the distance of honeycomb from the ground level ; (iv) host-comb relationship ; (v) nectar, pollen grains and colour of honey and (vi) phenology of forest plants, as also other aspects of the honeybees. The observations have been statistically analysed. The ecological aspects of *Apis dorsata* (Fab.) has been investigated in the estuarine tract of Sundarbans and such a study will facilitate in determining the optimum schedule of the period of honey collection. The results of the present study will be significant. The honeybees—*Apis dorsata* (Fab.)—migrate between

March and June every year in the vast expanse of the tidal swampy forests of the Sundarbans. Numerous swarms of these honeybees go flat out into ceaseless activity for collection of nectar, and other kinetic actions. There is a definite host-plant preference for making honeycombs and *Excaecaria agallocha* contributes approximately 39 per cent of honeycombs. *Ceriops* species contribute 11 per cent of honeycombs, but occupy about 90 per cent of the forest areas. Honeycombs made early in the season are found bigger in size than those made in the later period. The optimum distance of honeycomb from ground level, contributing to the maximum yield of honey, had been observed to be 2.5 metres. In 7.3 per cent cases, a second comb is constructed on the left away waxy base of the first comb.

The vast expanse of tidal swampy forests of the Sundarbans is the place where the honeybees (*Apis dorsata*) migrate between March and June every year. Numerous swarms of bees are flung into ceaseless activities in collecting nectar from vast tracts of mangrove forests, forming huge low comb, contrary to high level ones, close to the ground level.

A study has been afoot to ascertain (i) the percentage of different plant species that form the host-plant of the honeybees, (ii) if the bees are selective of any particular plant or plants for making combs and what is the percentage of different host-plant species, (iii) if the comb size has any relation to the quantum of yield of honey and wax, (iv) if the height of combs from the ground level has any nexus with the yield of the honey and wax, (v) if the pollen analysis of honey samples can indicate the nectar preference for any particular flower or flowers and (vi) the peak period of production.

VI

Innumerable honeycombs were inspected in different parts of forests over a wide area. The measurements of length, width and thickness were noted *vis-à-vis* honey and wax production of each comb. An umpteen number of honey collectors were also interrogated and their observations recorded. All these observations were later summarised. Samples of honey were microscopically examined and the host-plants were identified from the pollen grains. The total collection, from time to time, was enumerated

and correlated with flower production ; fortnightly collection of honey was measured and this exercise was continued for a period of 75 days.

Host-plants formed the following percentages for making honeycombs :

Avicennia species	16.0%
Heritiera fomes	9.0%
Xylocarpus granatum	2.8%
X. gangeticus	1.9%
Rhizophora mucronata	10.0%
Ceriops species	11.0%
Aegialites rotundifolia	1.0%
Excoecaria agallocha	39.0%
Aegiceros corniculatus	0:5%
Sonneretia apetala	5.3%
Bruguiera gymnorrhiza	3.5%

It is noticed that *Excoecaria* trees are obvious choice, although this tree does not either form suitable crown or have spreading branches. *Phoenix-Excoecaria formation* forms an ideal habitat for the honeycomb formation. The temperature and moisture laiden tunnel formed by *Phoenix* palm, with the *Excoecaria* branches having thickets, have maximum number combs per unit area. Against this, *Sonneretia apetala*, the tallest and the most branchy tree in the Sundarban forests does not hold sufficient number of honeycombs. The *Xylocarpus* species are avoided by the bees, although the trees have thick and dense crowns and are branchy. The *Heritiera* trees with their sporadic occurrence and light thin crown have quite a good percentage of combs in them. The *Rhizophora* and *Avicennia* (*A. alba* and *A. officinalis*) have proportionately high percentages of combs, although the trees grow only along the island boundary and beside the creeks, khals and rivers.

All over the forests 750 honeycombs have been measured. The width and thickness of the honeycombs are found rather constant in all cases while the length is variable, as indicated hereunder :

	Length	*Width*	*Thickness*
Maximum	120 cm	95 cm	7.5 cm
Average	75-90 cm	37-45 cm	6 cm
Minimum	37-45 cm	25 cm	6 cm

Endeavours made to trace out relationship between honey-yield with the length of the honeycomb and the distance from the ground level show that greater is the distance of the comb from the ground level, higher is the yield of honey, up to a height of 2.59 metres. Increase in height beyond that sets in the economic law of diminishing return.

Honey-yield corresponding to all available sizes of honeycomb has been noted. The results of yield with sizes and distance from the ground level have been analysed. It has been found that combs of one cft. volume yield about 3 kgs of honey ; combs of 1.25 cft. yield about 4-6 kgs ; combs of 1.5 cft. gives about 10 kgs and that of 2 cft. about 14 kgs, but the last two sizes are not of general occurrence.

The honey output depends on various factors, viz., (i) proper strain of honeybee, (ii) ideal weather condition, (iii) size of the comb, (iv) first or second formation, (v) distance from the ground level and (vi) optimum flowering of tree species, beside other factors.

A swarm of bees generally form only one honeycomb on a tree, however, branchy and wide-crowned the trees may be. It is only in 5 to 10% cases that two honeycombs are formed on a tree. In such cases, one becomes bigger than the other. This perhaps is formed when there are two queen bees in a swarm. Not a single tree has been traced with three combs. Generally, all the combs are constructed on a new site. Although the waxy bases of honey-combs are left out on the branches to invite the honeybees to form combs for the second, it has been found that only in 7·3% cases a second comb is constructed on the abandoned waxy base of the first hive. The combs on the slanting branches have been found to yield more honey than those on the horizontal branches. Honey accumulates on the lower portions of the comb.

It has been found that combs constructed early in the season are larger in size. The combs facing right angle to the sun have high honey contents. The characteristics of honeycomb have been shown hereunder :

Height Range of host trees	*Distance Range of 98% of host trees from ground level*	*Distance Range of 2% of host trees from ground level*
5 to 10 metres	1.5 to 2.5 metres	More than 2.5 metres

The phenological pattern shows the peak period of flowering of different species of flower-plants. This can be divided into several 15-day phases as follows :

Time of collection	*Host species*	*Colouration of honey*	*Percentage collection of honey*
March 20 to April 5	Aegiceros corniculatus, Acanthus illicifolius, Suaeda maritima	Creamy white	—
March 31 to April 15	Phoenix paludosa, Cereops species	Reddish	40.8
April 15 to May 5	*Sonneratia apetala*	Yellowish in colour and light reddish tinge light	53.2
May 1 to May 20	*Avicennia species*	do	do
May 20 to May 31	Excaecaria agallocha	Reddish colour	4.4
June 1 to June 15	Mixture of many species including Sonneratia apetala Avicennia species and Excaecaria agallocha	Reddish colour	1.6
		Total	100.0

The bulk of honey-yield is obtained from *Aegiceros corniculatus*, *Xylocarpus* species, *Acanthus illicifolius* (a shrub), *Phoenix paludosa* and *Cereops*.

Similarly, the honey collected during the latter half of April is mainly from *Sonneretia*. The last phase of collection is done from a mixture of many species of which *Excoecaria agallocha* contributes about 60% of the total amount of collection (as verified from the pollen's study).

Analysis of a few samples of honey under the microscope, however, shows the pollen grains of several species which do not even occur in the reserved forest area or in the vicinity. Such analysis shows a good quantity of pollen, the pollens of *Crotolaria* and several other species which do not occur in the Sundarban forests.

Nectar is a product of glandular secretion. All the flowering trees of the Sundarbans have small and fragrant flowers of *Acanthus illicifolius* and *Derris* species and grow bigger flowers. Nectar and pollen grains are used as fodder for the bees. The colouration in honey, it is held by some experts, is due to climatic conditions and also owing to the chemical composition of the nectar. The pollen grains of the following species have been found mixed with honey, which also impart colour to the honey:

Acanthus illicifolius	Yellow pollen grain
Rhizophora mucronata	Cream coloured pollen grain
Bruguiera gymnorrhiza	Vermilion coloured pollen grain
Xylocarpus species	Yellow to deep brown pollen grain
Ceriops species	Cream coloured pollen grain
Phoenix paludosa	Red coloured pollen grain

Sundarbans provide favourable climate and environment for *Apis dorsata* (Feb.) to make honeycombs during March to June. The dense mangrove vegetation with profuse nectar-yielding fragrant flowers attract the swarms of rock bees. The humidity during this period varies from 75 per cent to 85 per cent which is ideal for comb formation. But the rock bees detest continuous rain and bright sunny days, the former being detrimental to flush of flower and the latter for change in optimum humidity and temperature level. Sunny days with intermittant showers are ideal for honey production.

The honeybee operates in an area where the entire land mass is flooded with high-tide and the land animals have to lead an amphibious life. The most important land animals are tigers, spotted deer, pigs and monkeys (*Macaca mullata*). Honey is very much liked by monkeys and tigers and they do break the low-hanging combs for drinking honey ; monkeys are said to be smearing their body with a thick layer of silt before approaching the combs to escape from the pangs of bee-bites. Crabs (*Scylla*, sp., *Portunnus* sp. and *Mutala* species) have been found to cling on to the combs. Even though some aquatic mammals like little porpoise, lizards (*Varanus* sp.), terrestrial snakes (*Naja* sp.,

Dryophis sp., *Python* sp.) and *Crocodilus porosus* live near the low lying combs, the honeybees are unconcerned. It is not known why the combs are made within easy reach of the animals. Gastropoda (*Nerita* sp., *Telescopium* sp., *Melongena* sp., *Lymnaea* sp., *Onchidium* sp.) must be associated with the comb in one way or the other.

Honey collection as a profession is associated with a tragic human problem. On an average about 1000 honey collectors are engaged each year in this profession of whom at least 10 men fell prey to man-eaters and another 30 amongst them are attacked and rifled off by daring bandits. The average quantity of honey collection is 450 quintals and that of wax is about 40 quintals for the last twenty years.

VII

West Bengal holds an important position in pisciculture. This State has the advantage of all types of captive, culture, fresh water and brackish water fisheries.

A survey in the forest areas of the Sundarbans indicates a total annual catch of fish to the tune of 2500 metric tonnes. On an average, 4000 persons are engaged in daily fishing activities with 1.5 kilogrammes of fish-catch per capita per diem. From September to February every year on an average 6000 persons remain tied to fishing activities, directly or indirectly. About 70% of the total catch is done during this period. Chakrabarti, Kalyan and Chaudhuri, A. B. had studied on the subject and recorded observations in different technical articles.

The following facts account for the steady decline in fish-catch in the Sundarbans estuaries :

(i) Competition is keen among fishermen for catching fish—the number having risen 8 times since 1962 (500 fishermen) —who remained daily engaged every year between 1962 and 1965. Such competition induces over-catching of fish which, in a biological sense, is a condition of the stock in which, due to irrational catches, the number of individuals are incapable of reproducing under the optimal conditions and therefore can not ensure the maintenance of the stock, i.e., when the reproductive capacity of the population cannot commensurate with the losses due to over-catching.

(ii) The fast rate of siltation has made rivers/creeks rather shallow and difficult for fishing.

(iii) Percentage of salinity has shown a steady rise in all the rivers/creeks which is detrimental to fish-breeding.

(iv) Catch of brood and immature fish in the estuaries.

CATCH OF FISH DURING TWELVE MONTHS

Month	*Catch in Tonnes*
January	305
February	300
March	125
April	115
May	90
June	95
July	150
August	175
September	294
October	276
November	285
December	290

Statistical analysis has been carried out to find the length-weight relationship, if any, and coefficients of condition have been establised for 4 economic fish species, viz., *Hilsa ilisha*, *Mugil parsia*, *Mugil tade* and *Lates calcarifer*.

The following length-weight relationships have been obtained :

(1) $W=166.0\ (L)^5$ for *Lates calcarifer*.
(2) $W=.015\ (L)^3$ for *Mugil parsia*.
(3) $W=0.46\ (L)^2$ for *Hilsa ilisha*.

Where W stands for weight in grammes and L for length in centimetre.

Hilsa (*Hilsa ilisha*) :

Average length of the fish varies between 24 and 48 centimetres, while the weight varies between 125 grammes and 1950 grammes ; the coefficient of condition is 1.29 at 29 cm length, while it is 1.95 at 46 cm length which is the maximum.

Bhetki (*Lates calcarifer*) :

The average length varies between 20 cm and 97 cm and the weight varies between 100 gms and 4100 gms ; the coefficient of condition is 2.55 at length between 38 and 16 cm ; then the value decreases.

Bhangan (*Mugil tade*) :

Average length varies between 15 cm and 62 cm, while the weight varies between 30 gms and 3000 gms ; the coefficient of condition is 2.74 (a maximum value) and at length it is 28 cm.

Parse (*Mugil parsia*) :

Average length varies between 12 cm and 19 cm while the weight varies between 20 gms and 110 gms ; the coefficient of condition is 2.19 (a maximum value) which is attained at a length of 16 cm.

SIGNIFICANCE OF THE COEFFICIENT OF CONDITION

The coefficient of condition is given below in a formula :

$K=\frac{10^5 \times W}{L^3}$, where W is weight in grammes and L is the length in millimetre.

The coefficient of condition is dependent upon the food supply and calorific value of the food, in addition to other factors. It is therefore uneconomical to catch fish before they reach the optimum value of coefficient of condition. The coefficient of condition is being calculated for other fish species. For scientific exploitation of fish species, it is necessary that fish species which has not attained the optimum value is not caught. The optimum coefficient of condition also indicates the age of attaining maturity. An evaluation of coefficient of condition has not been made for the fishes of Sundarbans estuaries.

It will be necessary to find out whether coefficient of condition suffers from seasonal fluctuations. This value may be also calculated for fish species found elsewhere to ascertain the effects of saline environment upon the fish fauna.

In organizing a rational fishery to ensure a high productivity

of the stock of commercially important fishes, it is necessary to adopt the following protective measures :

1. To ensure the capture of fish of a size and age at which the highest production of good quality fish is obtained, and the fish supply is used most rationally.
2. To ensure replenishment of stock preserving the normal course of reproduction and the development of the larvae.
3. To catch fish in those places and times of the year when they reach a high quality and where the coefficient of condition is maximum.
4. To capture the fish at a time when they have mostly finished their feeding period and exhausted their food supplies.
5. To pass a suitable legislation reflecting all the above points and adopting the minimum type of mesh of fishing nets and also restricting to the rotational fishing.
6. To raise the productivity of a water-mass through introduction and acclimatization of new commercial fishes and even food organisms for the fish and identifying quickly the regions of maximum fish concentration.

Technology alone cannot bring about improvement of fish resources without simultaneous biological actions.

VIII

Preliminary investigations have shown the presence of about 50 species of Diatoms, 30 species of green algae and about 18 species of blue-green algae in the eastern Sundarbans region. Further investigation is necessary to register the presence of many more species, the evidences of which have been recorded. The maximum concentration of fish species is noticed in the Thakuran river which lies in the western part of Sundarbans. The Thakuran river significantly abounds more in fish species than those in other rivers/creeks appeared in the sample.

The available literature does not mention one Coelathrum species and one Ulva species which are very abundant in the supply of the pneumato-phores and trunks of those which are periodically inundated. These two algae have been found in stomachs of *Periopthalmus* and *Bolepthalmus* (mud-skippers), *Pangasius pangasius*, *Pampus chinensis*, *Mugil tade* and several other fish species.

Plotosuscanius and *Pangasius pangasius* fish have been found to feed themselves avidly on the fruits of the Keora (Sonneratia apetala) and Baen (Avicennia species).

In fact, during the months of August, September and October, tonnes and tonnes of fruits fall on water when these fishes concentrate near the bank and devour them. One *Pangasius pangasius* fish was found to weigh 12 kgs and it was found to have stuffed its belly with about 1 kg of *Avicennia* fruits. This fish had layers of yellow fat deposition.

The growth of fish and fat contents indicate that these vegetable food-stuffs are responsible for (i) fat deposition and (ii) growth. These data have been analysed and a suitable coefficient of correlation was calculated which has corroborated the relationship theory.

It is not clearly known if this growth hormone has any significant effect on fish and even on deer, birds, monkeys and men that feed either on leaves or fruits of *Keora*. Researchers are working on root and bark, stem and bark, leaves and fruits of most of the mangrove species for alkaloids, steroids, etc. Their findings will be significant, if combined with bio-ecological observations. The *Baen* leaves are heavily infested with insects and pests (Hymenoptera). The defoliation is likely to affect flower and fruit production, resultantly migration of *Pangasius pangasius* and *Plotosus canius* may be seriously affected.

IX

Fish forms the principal food for many bird species of this tract. Almost 100% of food of little cormorant consists of fish alone. An adult little cormorant consumes about 100 gms per day, while the estimated food of its fledgling is about 30 gms. *Channa punctate*, *Anabas testudinous* form the food for openbill. While *Pangasisus pangasius*, *Mystus gulio*, *Aplo cheilus panchax*, *Anguilla bengalensis*, *Muraena tile*, *Strongylura strongylura*, *Chelon spp.* and several other species of fish form the food for the large egret. In the case of little cormorant, the food consists mostly of the following fish species : *Mystus gulio*, *M. vittatus*, *Chela spp.*, *Puntius sarana*, *P. ticto*, *Catla*, *Labeo bata*, *Mugil tade*, *Anabas testudinous*, *Channa punctate*, etc.

5

The Wildlife Heritage

Heritage of wildlife is a proud possession of any country. It plays an important role in maintaining an ecological balance in the region. The feudal concept of the values of wildlife, as imparted in the words 'games' and 'sports', is presently giving way to a rational evolution of all life-forms as an integral part of the ecosystem. But the importance of the wildlife is hardly understood by the people. They do not hesitate to wipe out the flora and fauna for their immediate individual gains. During the last 400 years, about 95 species of birds and 40 species of mammals have become extinct and about 200 species of birds and 400 species of other animals are currently languishing and are in the process of extinction, mostly due to anthropogenic causes. The condition is equally serious in the densely populated industrialised areas and also in the intensively/extensively cultivated State of West Bengal. Vast forest-draped areas and quite a number of faunal species have disappeared since the turn of the present century ; more will follow in course of time as the land hunger keeps on rising with population explosion in this State. Over the last decade or so, there has been a some awareness about the necessity of preservation of basic life-supporting systems, including the flora and the fauna. A large section of the population has been very articulate on the question of preservation of generic and specific diversities of flora and fauna. West Bengal as a State has a fairly wide diversity in forest ecosystems, starting from the Rhododendron scrub forest in the Alpine Zone to the mangrove ecosystem in the Sundarbans. In West Bengal, out of a total forest area of 11,879 square kilometres, an area of 4048 square kilometres forms the wildlife reserves of the State, distributed

in fourteen wildlife sanctuaries, including two Tiger Project Reserves—one in Sundarbans and the other at Buxa Tiger Reserve—and other wildlife conservation areas. This accounts for 34% of the total forest area of the State. These wildlife conservation areas are situated in three different ecological formations, like North Bengal forests, South and Central Bengal forests and the forests of Sundarbans mangrove.

II

In the North Bengal forest ecosystems, wildlife sanctuaries at Jaldapara, Gorumara, Chapramari, Mahananda, Senchal, Jorepokhri Salamandar, Raiganj harbour a wide diversity of faunal species. In the laterite areas of South and Central Bengal, wildlife sanctuaries, such as Ballavpur, Bibhutibhusan Sanctuary, Ramnagan and Narendra Sanctuaries comprise well demarcated conservation areas, promoting and protecting varied faunal species. In the Sundarban Swamps, the only National Park of the same name exists in this State. These apart, wildlife sanctuaries, like Lothian Island, Halliday Island, Sajnakhali and Bhagabathpur Crocodile Conservation Farms provide ecologically significant areas. There is a research centre in the State for wildlife conservation. There are deer parks such as Adina Deer Park in Malda, Daw Hill Deer Park in Darjeeling, Jhargram Deer Park in Midnapore, Kumari and Kanasabati Deer Park in Bankura and Purulia respectively and a deer research centre at Salt Lake, Calcutta. The highlights of different wildlife reserves reveal an interesting stock of ecological information.

SENCHAL WILDLIFE SANCTUARY

The Senchal Game Sanctuary of Darjeeling established in 1915 is the oldest sanctuary in the country. The total area covered by the Sanctuary is 38.60 square kilometres. This was declared a 'Wildlife Sanctuary', in 1976. It is situated at an altitude between 1500 metres and over 2600 metres. This Sanctuary serves as the principal water supply source for the hill town of Darjeeling. This Wildlife Sanctuary encompasses both natural forests and plantations, the plantation area covering about 60 per cent of the total area of the sanctuary. In areas between

2000 metres and 2500 metres of altitude, oak trees form the top canopy. Other associate floral species are *Kapasi*, *Katus*, *Champer*. Sub-tropical flora is found on the ground between 1500 metres and 2000 metres with *Meliosma Wallichi*, *Machilus edulis*, *Alnus nepalensis*, *Prunus species*, etc. *Michelia Champala* and *Rhododendrons* are found in higher echelons. The plantations comprise *Cryptomeria japonica* mixed with *Michelia Champala*, *Tsuga brunoniana*, etc.

The faunal species are represented here by barking deer, wild pigs, goral, serow, Himalayan black bear, leopard, jungle cat and leopard cat, common Rhesus, Assamese macaque, Indian Civet, Himalayan flying squirrel, Himalayan jackal and wild canine species. The sanctuary abounds in rich avifaunal species, like large yellow-naped woodpecker, emerald cuckoos, khalij pheasant, red jungle-fowl, babulers, sun-birds, etc.

This Sanctuary is situated at about 11 kilometres away from Darjeeling town, near Jorebungalow. The Tiger Hill located in the Sanctuary area, is famous for its scenic beauty and panoramic sunrise which people at home and abroad come to see and enjoy.

JOREPOKHRI SALAMANDAR WILDLIFE SANCTUARY

An area of about 4 hectares, forming a small lake, at Jorepokhri which is situated at a distance of about 25 kilometres from the Darjeeling Hill Station, shelters an extremely rare species of amphibians called the Indian Salamandar (or Himalayan Newt scientifically, *Tylototriton verricosus*). This tract has been declared by the Government as the wildlife sanctuary in 1985. In European countries, Salamandars, like Dodo, became extinct about 20 million years ago. The nearest town from the Sanctuary is situated at Sukhiapokhri.

MAHANANDA WILDLIFE SANCTUARY

This sanctuary, first set up in 1949, is situated in Darjeeling district within the jurisdiction of Siliguri township. It was later re-notified by the Government as a wildlife sanctuary. It has an area of about 127.22 square kilometres. This tract is based between two large rivers, viz., the Teesta and the Mahananda. Roughly, 60 per cent of the area falls within the hilly region, while

the rest comes within an elevation between 150 metres to 1200 metres.

Here, the plain forests are represented by Shorea robusta (*Sal*), *Acacia Catechu* (*Khair*), *Dalbergia Sissoo*, *Albizzia lebbek*, etc. The lower hill tracts are represented by *Lagerstroemia parviflora*, *Gmelina arborea*, *Cedrella toona*, *Ailanthus grandis*, etc., while the hilly tracts are covered with *Talavma hodgsoni*, *Betula alnoides*, *Alnus nepalensis*, *Phoebe attenuata*, etc. Tree ferns and epiphytes are also common here.

In these forests, major wildlife includes elephants, gaur, leopards, wild pig, spotted deer, sambar, barking deer, etc. Lesser animals, like rhesus, jungle cat, porcupine, monitor lizard, civets are also found. This sanctuary is situated at a distance of about 20 kilometres from Bagdogra Airstrip.

GORUMARA WILDLIFE SANCTUARY

A game sanctuary since 1942, was declared a wildlife sanctuary in 1949. This sanctuary is situated within the district of Jalpaiguri. It has an area of about 862 hectares and presents a unique mixture of wildlife. Most of the area is low-lying flood plains of the Murti and the Jaldhaka rivers.

Existence of one-horned rhinoceros here holds a pride of place. The sanctuary covers high land and low-lying riverain forests. Other major faunas include elephants, sambar, barking deer, hog deer, etc. The sanctuary is replete with rich avifaunal species, like migrant birds during winter. National Highway No. 31 skirts the southern extremity of the Sanctuary.

CHAPRAMARI WILDLIFE SANCTUARY

This area, situated as it was in Jalpaiguri district, was notified a game sanctuary in the year 1940 and, later, it was renotified a wildlife sanctuary. It covers an area of about 960 hectares. The river Murti flows along the western boundary of the sanctuary.

The forest produces a dry mixed vegetation consisting of *Shorea robusta*, *Aphanamixis polystachia*, *Turpinia pomifera*, *Schimma Wallichii*, *Bauhinia species*, *Terminalia species*, *Stereospemun Chelonoides*, *Machilus species*, *Mallotus species*, *Dillenia pentagyna*.

The major fauna includes elephants, gaur, wild pig, sambar, barking deer, tiger, leopard, rhesus macaque, etc. This area is rich in various avifaunal species. The sanctuary is located on the roadside of Loherol Route (NH 31A) to Jaldhaka Hydel Project. Chaoramari Railway Station is about 2 kilometres from here.

JALDAPARA WILDLIFE SANCTUARY

Initially a game sanctuary in 1941, this was re-notified as a wildlife sanctuary. The Torsa and the Malangi rivers zigzag through the area of this sanctuary. The wildlife sanctuary, situated in Jalpaiguri district, covers an area of about 116 square kilometres.

The sanctuary has a broad diversity of flora (forest types)—ranging from Savannah to riverain and dry-mixed, wet-mixed and *Shorea robusta* forests. Grasslands contain *Saccharum*, *Imperata*, etc. Riverain crop includes *Dalbergia Sissoo*, *Acacia Catechu*, *Bombax malabaricum*, *Albizzia lebbek*, etc.

This sanctuary is the abode of the largest concentration of the scared away population of the one-horned rhinoceros, in West Bengal. Besides, there are tigers, elephants, gaur, sloth bear, sambar, barking deer, hog deer, leopards, wild pigs, jungle cats, otters, etc. Evidence of the presence of Hispid hare has been found recently. This sanctuary is also rich in bird-life, including winter birds.

The nearest town of this sanctuary is Madarihat, situated at about 6 kilometres away on the National Highway No. 31 and the Meter Gauge rail-line. The nearest airstrip with Vayoodut service is based at Cooach Behar, about 62 kms to the East.

BUXA TIGER RESERVE

It is located within Alipurduar Subdivision of Jalpaiguri district, covering a total area of about 758.82 square kilometres. It was first a Tiger Reserve during 1982-83. The core area of this Reserve, covering an area of about 315 square kilometres, was proposed for declaration as a national park, while the remaining land as a wildlife sanctuary. Most of the forest areas were under Government control since 1866. It formed some of the oldest reserved forests in the country dating as far back as from 1879.

The area lies in the moist-tropical zone. The altitude varies from 150 metres to 2000 metres in this reserve. The area is criss-crossed by rivers, like the Pana, the Dima, the Bala, the Raidak, the Jainti, the Gaburbasra and the Sankos. *Sal* forests extend over the larger part of the plains and foothills.

A concentrated tiger habitat in North Bengal. Besides, there are leopards, leopard cat, jungle cat, wild dog and other carnivorous animals. Herds of elephants and gaur are also occasionally seen during their migration. Cheetal, sloth bear, wild boar, sambar, barking deer and thar are also observed sometimes in this reserve. Minotor lizards, snakes are also met with. This Tiger Reserve is also rich in bird species. The eastern boundary of the Reserve is formed by the National Highway No. 31A. The nearest airport is Cooch Behar at a distance of about 40 kilometres.

III

Three important animals have put the West Bengal forests on the world map. They are : (1) the one-horned rhinoceros, (2) the Indian elephant and (3) the tiger. The existing rhinos are regarded as the living fossils, marking a stage of evolution of this species about 60 million years ago, and tracing their ancestors to the Hyrachus of the tertiary age. The small Sumatran Rhinos have totally disappeared from the Sundarban swamps. Their number has dwindled to the point of extinction in Burma, South Siam and South Borneo. The Jaoan lezzer one-horned Rhinos are struggling for their survival in the Indonesian sanctuary of Udjung Kulon. The African kinds, namely, the hook-lipped and the square-lipped two-horned ones are somewhat in a better position with about 1500 members at the last count. Rhino-horn trade in Asia having diminished, the traders in this commodity from Hongkong are now turning their eyes towards Africa. The Survival Service Commission of the International Union of the Conservation of Nature and Natural Resources once toyed with the idea of putting some artificial substitute for powdered rhino-horn on the market in large quantity, but ultimately the idea was dropped as unethical. It is a pity that the need for elixir and aphrodisiac has been exploiting such a rare and expensive material as the rhino-horn. The spread of education and marketing of genuinely effective aphrodisiac will obviate the demand for the

exotic rhino-horn. Unless this is done, and informed opinion prevails over superstition, the animal will have to survive only under the protective care of sanctuaries and reserves.

The Rhinoceros belongs to the natural order of Perissodactyla or Odd-toed Ungulates. This genus has three toes each on their forefoot and hindfoot. Their dentition is characterised by molar and pre-molar types in one unbroken series. *Rhinoceros unicornis*, the only species available in India, is distributed in Nepal, in the countryside to the East of the river Gandak, in Bhutan duars, in West Bengal duars and in isolated places in Assam plains. The distribution of rhinos was, however, more widespread and their number was also large. Even though the genus Rhinoceros today is restricted to the old world, as found from the fossil studies, it is seen that the distribution of these animals was widespread and the number was abundant in Europe throughout the Pleistocene and early Pleistocene periods. The oldest of them has been recorded from the Eocene bed of America. It has been recorded that the ancestors of Rhinoceros, which lived in America, migrated to India in the Oligocene-Miocene period. In the historical period, the Rhinoceros distribution was very extensive as found in the Mahenzodaro-Harappan period. The presence of Rhinoceros-seals with lifelike representations indicate their presence in the Mahenzodaro-Harappan areas about five thousand years ago. Babur, in his Memoir, has often mentioned the presence of Rhinoceros in different parts of northern India. Abul Fazl mentions Rhinoceros in the Sambal Sarkar of Delhi Subah in Akbar's reign. William Finch, during his journeys in 1608-11 to different parts of India, describes that Ayodhya was a great centre for sale of products made from Rhinoceros horns. Even some 80 years back, the Rhinoceros was reported to have been seen in the forests of Malda district in West Bengal.

The present status of Rhinoceros presents a dismal picture. The reasons are not far to seek. Shrinkage of habitat, greed and attraction of the avaricious men for the horns, indiscriminate poaching incidences and pressure on land have practically pushed this gigantic creature to the peril of extinction. This animal is now badly in need of strict protective measures.

IV

Elephants (Elephas maximus Linn) are the largest and heaviest among the terrestrial animals of the world today. Their number has dwindled to about 12,000 (twelve thousand) only in India and is facing the mightiest challenge from an ever-expanding human population. Their survival lies in the management and conservation of their habitats. Depletion of forest cover and fragmentation of large blocks of forests into smaller ones, increasing human population and their settlements, have brought about abrupt changes in the movement and behaviour of elephants. There is dearth of foodder, green pastures and even of resting places.

Gigantism is the forerunner of extinction of all the biological beings. Mighty trees and animals have either vanished or are in the process of being annihilated and these are now considered as the 'living fossils'. Past experience has shown that migratory and resident elephants do not maintain any fixed boundary limit, nor do they stray very far away from their regular tracts. Crowding of herds indicates a drastic change in the habitat and destruction of migratory routes leading to loss of animal-habitat equilibrium. The shrinkage of habitat is the key problem in West Bengal. This has brought human beings into direct confrontation with these gregarious animals and, as a result, they are forced to take refuge in agricultural fields, homestead lands, farm houses and open forests. This direct confrontation has earned for the elephants maltreatment from men. Hence, some of them turn out to be 'rogues' and they cause devastation to human life and property. The man-elephant relationship requires to be understood in-depth in order to take some effective measure in tackling the problems of the elephant depredations and destructions.

In order to protect the habitat, the entire vegetational matrix in all its tiers are to be maintained. Elephants co-exist with all species of herbivorous animals in the forests and do not compete with their food, like bamboo-sprouts, tall grasses and tree-leaves at a certain height. In the tropical heat of sultry months, they need soft undergrowth to ward off unbearable irritating heat, moist shade, plenty of edible leaves, fruits and adequate water. The problem of protecting the last vestiges of Indian elephants in the State of West Bengal has assumed serious

proportion in view of the large-scale depletion of vegetal cover and corridors. This situation warrants immediate curtailment of forestry operations to a bare minimum, so as to be able to manage the habitat on a planned basis against exploitation.

Behaviour study of the lone bulls or rogues is a worthwhile exercise, inasmuch as no wild animal other than elephant has served men more faithfully through ages and has been made the subject matter of myth-making and fanciful story-telling. Docile nature, courage, endurance and freedom from vices are the few attributable appellations to elephants. They occasionally go berserk and make unprovoked attacks on men from behind. Rogue elephants may be either inherent or designed killers or are acquired ones. Amongst the acquired killers, there are adventurous killers, habitual killers and circumstantial killers. Habitual killers frequently kill men, destroy property and are vindictive, with evil desings. Circumstantial killers are the products of induced injury, ill-treatment by men. They cause about 40 per cent of the total human kills, while the proportions of human loss due to adventurous killers and habitual killers are 20 per cent and 15 per cent respectively. The remaining 25 per cent human kills due to this animal are from inherent rogues who suffer from temporary loss of sanity, due to deep-rooted causes in case of domestic elephants. These sets of information have been obtained from statistically designed surveys conducted in North Bengal forests.

V

The dry deciduous forests on the lateritic soil in the western part of West Bengal, potentially a good habitat for a variety of faunal species, is now almost bereft of any significant wildlife population, due to large-scale biotic interference and annual tribal hunts. Small herds of wandering wild elephants, which regularly stray into these forests from the adjoining ones in Bihar, and an occasional glimpses of wolves, jackals, rabbits, jungle cats, fishing cats, civets and mangoose are the only wild animals inhabiting now in this part of the country. About the birds (other than the common ones), one may have chance meetings with our national bird peacocks, on rare occasions, red jungle fowls, button quail and patridges move about freely.

The commonly found reptiles are snakes, lizards, cobra, krait, viper, gecko and monitor. The pythons have become fewer.

Once rich in forest products, the Central districts of West Dinajpur, Malda, Murshidabad and Nadia in the Ganges basin are today mostly devoid of adequate vegetal covers. The reasons for this are : population pressure, expanding cultivation, unrestricted grazing and indiscriminate felling of trees. The prominent tree forests today in this area are man-made.

VI

Among the birds in this State, the most magnificent, fascinating and brilliantly coloured one is our national bird the Peacock. This bird of unmatchable beauty with its gorgeous plumage and majestic dance, brings to our mind various cherished images and rhythms in life on account of its close association with our art, literature, folklore, religion, legend, rituals and ceremonials. The Rigveda, the oldest Sanskrit text, contains several references to the virtues of this national bird. Legend has it that Lord Krishna used to adorn His head with its colourful plumes. In the culture of other countries also, it occupies a conspicuous position. This beautiful bird belongs to the family of Pheasants (Phasianidae) and is broadly related to patridges, quails, spur fowls, snow cocks and Pheasants. The female ones are called the Peahens. The peacock, a cosmopolitan bird, can adapt readily and can be domesticated. Primarily, this bird abounds in large agricultural firms, gardens, groves and forests. It is essentially a denizen of the humid tropical forests of the country. It also loves to live in wet lands with luxuriant undergrowth, thick beds of reeds and grass, clusters of trees, tree-cover, open grassy space along the freshwater spots. From time immemorial, the peacock has been helping mankind in their material needs and are providing them with recreational facilities and inspiration. The close relationship between the man and the bird can be traced back to historical ages. Its antiquity can be inferred from the fact that the autochthons have taken this bird in their customs and beliefs even today. Besides its decorative and recreational values, the peacock has many other uses. It has good meat and palatable eggs which probably were eaten by the primitive people, including kings and nobles in the medieval period. The flesh has also its uses in the

preparation of medicines. An omnivorous bird, its staple food are seeds and fruits. It also eats bulbs, roots, tubers, grass, leaves, the nectar of flowers and sap. To its menu are added white-ants, which it extracts from termite mounds by scratching them vigorously with its powerful claws, so that the tiny insects are exposed from their hideouts. An enemy of snakes, it is essentially a bird of well-watered country. A shy bird as it is, the peacock dislikes intrusion by the mankind into its territory. When approached by a man, it keeps a safe distance by moving faster on the ground, warrily skipping through impenetrable thickets and stopping at intervals, peering inquisitively from under the bushes with outstretched neck and taking to wings only as a last resort. The peacock is an extremely keen observer with a sharp eyesight. The surreptitiously crawling large cats on the prowl are quickly detected and deterred by the peacocks. On sensing danger, it immediately raises alarm by repeatedly emitting the ear-spliting shrieks—'Pehaun, Pehaun'. An alert and intelligent bird it can easily smell friend or foe in a person. It runs away on seeing the enemy, but goes close to a friendly person and often signals him to save it.

The peacock occupies a prominent place in history, mythology, edicts, paintings, sculpture and numismatics. In India the bird is identified as the vehicle (Vahana) of Skanda or Karttikeya, the champion fighter and Commander-in-Chief of the Divine Army. The Mahabharata and the Puranas carry descriptions of Lord Karttikeya, mounted on the peacock, who defended Tripurari's chariot and destroyed Tarakasura. At Mayurapura, a hill in South India, Karttikeya was believed to have killed a demon who thereafter was turned into a peacock. This peacock was asked to serve as the vehicle of Subrahmaniam, the God of Yogic powers. The Rigveda mentions that War God Indra's horses possessed hair like peacock's feathers and tails like those of the peacocks. Valmiki's Ramayana contains an interesting account of Indra turning himself into a peacock to escape the wrath of Ravana, the indestructible Demon king of Lanka. Legend goes that Indra took the guise of a peacock and managed to escape the anger of Ravana and then bestowed upon the peacock variegated feathers with thousands of eyes, the powers to destroy serpents and to bring rain for the welfare of the mankind. The great Bana of the Mahabharata fame, used peacock as his banner. The

peacock was the totem of the Moryas, a name derived from the word 'mor' (peacock). According to Jain Scriptures, the peacock was used by Harinaigamesin, the Army Chief and god of the nativity as a vehicle. The bird is the emblem of Jaina Yaksha, Yakshini and Kumara attached to Tirthankara Vasupujya and Mahamanasi to Santinatha. Mahamayuri, the Buddhist deity also used this bird for a similar purpose. In Indian sculpture also a prominent place is occupied by this bird. A beautiful depiction of peacock comes from Chandraketugarh of 24 Parganas district in West Bengal.

It is not just an object of beauty. It has manifold uses, as food, medicine and also for decorative and ceremonial purposes. The flesh of the peacock was considered a delicacy in the past and it formed a regal dish to which our epics and Puranas bear testimony. The Ramayana mentions serving of peacock's meat in the banquet of Ravana. Two special medicines known as *Mayuraghrita* and *Mahamayuraghrita* prepared chiefly from peacock's flesh, in clarified butter, are said to be efficacious in various diseases, especially in restoration of virility. The peacock meat, when cooked with other animals' flesh, either in *Dasamulirasa* or *Kanlathharasa*, cures hiccups as well as asthma. Even today, peacock feathers are sold in South and North India. The burnt ashes from the feathers (*Mayurapuchhabbhasma*) is used as a remedy for vomitting. Oil obtained from the fat of the bird, known as *Mayilenna*, is used for the cure of rheumatism, gout, arthritis, sprains and dislocations.

But this ever-useful bird is a rarety in this State, as it cannot live in the natural conditions here. The national bird is now included in Scheduled I of Wildlife Protection Act, 1972 as an endangered species.

VII

The faunae are in the habit of depleting themselves and in this process some of them have been wiped out from the earth. Illegal and reckless poaching made them fewer in number. With the promulgation of the Wildlife Protection Act of 1972 and the concomitant rules made thereunder, the Government of West Bengal have taken some legal steps to combat these problems.

Public education and their awakened consciousness can show the way to the successful implementation of laws and rules in this regard.

VIII

No one could have possibly imagined fifty years ago that a desperate situation would require the Sundarban Royal Bengal Tigers, the unquestioned king of the forests, to be saved from total extinction. Tiger, the supreme predator of the forest, is now is dire need of human help for survival as a species, known to be dangerously blood-thirsty carnivorous animal men are afraid of. E. P. Gee, a renowned naturalist (1966) estimated that there were 40,000 tigers living at the end of the 19th century, but a systematic State-wise census during 1969 put the number of tigers at only 2500 in this country.

At the apex of a large biological pyramid tiger is placed. It is possible to save the animal if the whole biome or its habitat can be properly maintained. This big-brother of the feline family keeps the population growth of the herbivores under check and saves the vegetation from being overgrazed and the land being denuded. It also maintains a good stock of stout animals by eliminating infirm, old and diseased ones. In other words, it prevents the upsetting of the ecological fulcrum of a given area and maintains the much-needed balance in nature. The Project Tiger is a bold nature-conservation Project for saving the animal from disappearing and for maintaining the balance of nature. The tiger constitutes the genesis of this unique movement of preservation of the natural ecosystem. Doubts arose in the minds of people about the propriety of preserving this noxious animal. But the whole thing was caviare to the general. Preservation of tiger is necessary to ensure the human existence and to maintain the inescapable necessity of having ecological balance in nature. Project tiger is surely not a project for artificial breeding of tigers—it is an attempt for conservation of nature, and is designed to conserve the entire ecological fabric in natural ecosystem of which the tiger is an integral part.

It is not possible to preserve the tiger population in isolation without conserving the entire chain of food-supply in nature. The animal has an amazing adaptability. It is able to live under

extreme variants of natural conditions, from the snow-laden north to the arid deserts, and even in the inhospitable preumato phore-studded mangrove swamps, where the water is extremely saline. But human greed and abysmal indifference about the overuse of natural resources, has led the tigers into a situation where it has left them to depend on the mercy of man for their existence. Project Tiger was drawn against this backdrop to ensure and perpetuate the human existence through maintenance of a well-knit ecological balance in nature.

The reasons why the tiger population is fast depleting are over-hunting, gradual shrinkage of habitat and depletion of its kills in the forests. The socio-economic relations of the tiger with man are the chief factors in this unfortunate depletion of tiger population.

Thanks to the conservationists, tiger population was not only prevented from being depleted further, but also was encouraged to increase in number with active participation of the people at large. Prevention of poaching has been of great help. Management of tiger resources has also ensured better conservation of soil and water and has resulted in a better and even dispersal of population. The dynamics of nature have, as a result, been significantly reactivated at both the producer and consumer levels. It is no wonder therefore that a low tiger population of 135 during 1973—the time when the Project Tiger in Sundarbans was initiated—has nearly doubled (present tiger population is 269) over a period of 16 years. As per 1989 tiger census conducted in India, the total number of tigers is enumerated as 4334 and in Sundarbans it is estimated as 269 during 1989.

'Project Tiger' has succeeded in correcting the human errors causing an ecological disaster. If we are to survive, there is no alternative to live in peace and harmony with the environment, which, if properly handled, will continue to give us the much-needed sustenance through preservation of our natural habitat. The charter of declaration of human environment in the United Conference of Human Environment at Stockholm, Sweden rightly resolved in the following words : 'Man has a special responsibility to safeguard and wisely manage the heritage of wildlife and its habitat which are now gravely imperilled by a combination of adverse factors. Nature conservation, including wildlife must therefore receive importance in planning for

economic development.' Tiger has thus a significant role to play in the basic life-support system of man.

IX

Man's basic life-support system consists of land, water, air, plant and animal resources in the biosphere. While the biosphere is richly endowed with renewable and non-renewable resources, human beings are multiplying at an alarmingly fast rate and, consequently, their demand for more and more resources is increasing. There is an old saying in Thailand to the effect that : 'Experience is a comb which Nature gives to man after he is bald.' It is the boundless neglect of man towards his own life-support system that gives rise to the ecological imbalance and disaster in nature. Man has been continually altering his environment in order to fulfill his short-sighted aspirations and thereby acting to the detriment of his interest. This is amply evident in extermination of many plants and animals from the face of the earth. Yet, India had been for a millenia the most favourite haunt of the tigers or the magnificient big cats. The tigers are now grimly struggling to survive .

The preservation of tiger is possible only by maintaining its entire ecosystem in optimum condition for supporting its viable population commensurate with the maximum holding capacity of the habitats. Sundarbans is a unique example of the bounty of nature, sheltering venomous snakes, sharp toothed sharks, lusty crocodiles, powerful and flamboyant tigers, delicate spotted deer and clumsy wild pigs, all together, presenting a sight of beauty and fury. It is a curiously anomalous tract where mud-skipping fishes crawl up the trees, during the tides in some creeks which run in the opposite directions, molluscs and crustaces are found abundantly, and high tides occur twice a day. Sundarbans has left the stamp of this peculiar environment upon all the plants and animals growing there. Each component of life in Sundarbans is bewitching, and its adaptability to this peculiar saline terrain has made each of them an absorbing object of study and research.

Sundarban tigers are wrongly branded as inherent and designed man-eaters. The author has, over a period of about nine years, studied the mangrove swamps of Sundarbans. Sundarban

tigers can be classified according to their behaviour pattern, into three broad categories, viz.,

Category I : This includes two sub-categories, of which one is inherent and designed man-eater (25%) and the other is non-maneaters (75%). The first sub-category is again subdivided into two microgroups : one is aggressive man-eater (80%) and the other lusty and adventurous (20%).

Category II : Undesigned man-eater (15%).

Category III : Circumstantial man-eater (60%).

Tigers falling into categories II and III obviously form the balance of 75% of the first category.

Sundarbans supports a fascinating habitat. The biological system is tough, resilient, adaptive and surely designed for survival but, it is complex, interrelated and interacting. It holds the brightest promise as the suitable habitat for the magnificient cat and also to support a compact biota for the perpetual maintenance of an integrated ecological fabric in nature.

The swamps of Sundarbans, a land of diverse ecosystem, have the largest tracts of estuarine forests in the whole world. It, covers about 10,000 square kilometres, one of the largest chunks of undisturbed forests forming an ideal habitat for the tigers. It becomes sometimes inhospitable when tidal action prompt a rapid circulation of nutrients and salinity varying widely, both vertical and horizontal planes.

The vast expanse of swamps studded closely with a network of tiny islands of mud flats support a low-wooded, highly dense forest of virgin beauty. The rivers around tiny mud flats form fantastic labyrinths and bifurcations where hard and pointed pneumatophores give a trying time to the dwellers of Sundarbans. Opposite, undirectional and oscillating tidal currents meet and exert considerable and complicated force for the entire biota. Diurnal changes of salinity in water creates conditions in which physiological adjustments of the animal and plant communities become difficult. Sundarbans Tiger Project area is a negative estuary where the influx of fresh-water is practically negligible. Tigers, in general, indicate euryhaline character as in many estuarine organisms.

A study of ecology of the Sundarbans, its tigers and their behaviour pattern shows some astounding bio-ecological traits.

Human casualty reported from all over the 15 Blocks (65

compartments), covering 2585 square kilometres of the Sundarbans Tiger Project area, shows the presence of aggressive man-eaters all over the Project area.

Migration of tiger from one Block to another and across the international boundary is a common feature, as the animal has been sighted negotiating vast expanses of water. This may be due to their search for elevated lands above the inundation level, and also for searching out the kills, specially human beings. On many occasions, such tigers have exhibited immense tenacity to combat odd situations and save themselves in the face of inevitable death.

The average annual human casualty has been reported to be 36, but unofficial reports put the figure at about 100 (the forest being contiguous to Bangladesh forests). Dead bodies could be recovered from the man-eaters only in about 28·5% cases. The balance of 71·5% were carried away the man-eaters themselves.

The number of human casualty fluctuates from the lowest figures during the rains to the highest figure during April and May. During these two months, the entire estuarine forests hum into ceaseless activities owing to millions of trees burgeoning new flush of leaves and flowers which invite myriads of swarms of *Apis dorsata* for constructing honeycombs all over the Project areas. This synchronises with the activities of all types of lives from molluscs, crustaces to *Homosapiens*. The cunning tigers seize this opportunity to kill a large number of honey collectors, besides fishermen, shell collectors, timber coupe workers etc., in this season.

The man-eaters have a diabolical understanding about human nature as they kill men between 7 A.M. and 8 A.M. and again between 3 P.M. and 5 P.M. when the workers just come out to the jungle and to their work site or prepare to return to their camps in the evening (80% human casualty). The most notorious and cunning man-eaters are those which swim to the boat on the river, mount on it, select their victim and jump into water with the dead body to return to the forests. This occurs around 11 P.M. mostly when the boatmen remain fast asleep.

The middle-aged men (between 35 and 45 age-group) are usually the prey in such attempts ; they find these men, more daring and indifferent towards self-protection. Such cases form about 80% of human casualty figures.

Salinity of water is probably the most important factor responsible for a good percentage (25%) of tigers turning into man-eaters. Salinity and salt tolerance capability of tigers—their osmo-regulatory mechanism, if any, adaptation to constant fluctuation of salinity level, effects of salt-water on kidneys, liver and the entire physiological system are thought to be the factors responsible for the aggressive behaviour of the tigers.

Pigs and deer available in abundance in forests are the primary prey of the tigers. The terrain, however, presents a serious handicap for the tigers to hunt animals. As such, they turn to monkeys, fishes, birds, crabs and even honey as alternative foodstuffs under trying circumstances.

Endogenous periodism is manifested in several estuarine organisms. The presence of a 'Biological Clock' on such organism has been suggested. The pattern of man-eating as manifested in the time of killing, maximum death rate in a Block, fluctuation at regular intervals, maximum casualty just before the full-moon and the new-moon, clearly point towards some form of 'Endogenous periodism' in the estuarine tigers (the mechanism is called Endogenous self-sustaining oscillation or, in short, ESSO).

Sundarbans forests need be conserved not only for tiger alone but also for acting as a natural barrier against severe cyclonic storm during the monsoon months. However acute might be the immediate public need, these estuarine mangrove swamps have to be preserved to fight against the mighty tidal wave of the Bay of Bengal and to protect the lives and properties of the millions of poor villagers residing close to the forests. 'Project Tiger' is essentially a nature conservation project.

The socio-economic, scientific and administrative problems in relation to Sundarbans tiger are specific and unique. Attempts to solve them will require considerable time and attention. The local people of the Sundarbans have a firm belief that death is an inevitability and it occurs according to the decrees of the Tiger-God—there is nothing that one can do to thwart it. They have reconciled to the situation and have evolved some kind of fatalism and coexistence with the man-eaters. The tiger is accepted as a cold reality in the life-style of Sundarbans men, and the people are only made to observe elaborate rituals of ground rules to ensure coexistence with the man-eaters. People embracing all sorts of religious faiths, sit together and pray to God, irrespective

of their social position, caste and creed, for their protection against this monster. This is the philosophy of man's relationship with the Sundarbans tigers. Sundarbans accepts both man and man-eaters in her ecosystem with perfect equanimity. Tiger is a living entity to the men of Sundarbans ; it is almost the obverse and reverse of their life-style.

X

The Sundarbans estuary is an ideal habitat for the estuarine crocodiles (*Crocodilus porosus*). Earlier, this species lived in umpteen numbers in this estuarine tract. But the number dwindled because of depletion of their accommodation. A project became necessary for their breeding and rearing purposes within their natural home. Bhagabatpur Crocodile Project of 24 Parganas District in West Bengal came up during 1976. Here, crocodile eggs are collected from their natural haunts and incubated artificially. For this purpose, there are hatcheries, hatching pools, yearlings, pools and a pool for the adult crocodiles. The yearlings, on attainment of the length of 1 metre or more, are released into the rivers of Sundarbans. So far, 242 crocodiles have been hatched and 204 yearlings have been released. An experimental hatchery for the Olive Rideley sea-turtle also has been established in this estuary. This crocodile project is located at Bhagabatpur which is 105 kilometres by road from Calcutta and 20 kilometres by river from Namkhana.

XI

The State Government have plans to improve the conditions of the wildlife by enforcing strict protective measures, viz., by earmarking suitable habitat zones for the sanctuary, by conserving and improving the wildlife population through special projects like Project Tiger, Captive breeding of the vanishing species, such as, crocodiles etc., by taking up extension work and by strict enforcement of the Wildlife Protection Act, 1972 and its concomitant rules. A number of deer rearing areas have been and are being created, which will serve the dual purpose of mass education and recreation. An action plan for the Wildlife sector has

been drawn up delineating the current and future needs, objectives and strategies to achieve the same by the Government which is underway in this State. This is being done in consonance with the World Conservation Strategy, which was launched in the country in 1980. But the conservation, however sound in concept it may be, is apt to fizzle out, unless necessary pragmatism goes into its formulation and implementation. Forest is a renewable and reusable resource, acquired by man in direct competition with wildlife. Instances of man-animal confrontations were in abundance. The Government have adopted a scheme for payment of ex-gratia compensation to the unfortunate victims of elephant and tiger depredations. This is sure to win some public support for wildlife management. Dissemination of knowledge of wildlife and inculcation of love and sympathy for the animals in public mind is necessary.

6

Man Plant and Animal Interaction

The study of three villages were chosen in three different agro-climatic zones of West Bengal with distinct socio-economic conditions, has thrown interesting results. One of the objectives of the study was to find out the plant-aminal relationship with villagers and to what extent such relationship influenced the pattern of living.

A village called Pump Basti, or Pampoo Basti (locally called) under Kalchini Police Station of Jalpaiguri District, has 36 households (total population 200 : Scheduled Caste 3, Scheduled Tribe 162, Others 17), reveals dependence on forests as secondary profession is on the increase among the Caste Hindu in the present generation, but as a primary profession it remains practically at the same stage for the last three generations. The percentage of dependence on agriculture is, however, on the decline from one generation to the other. In the field of daily labour and other miscellaneous professions, the prcentages are on the increase from one generation to the other. In the same village, however, amongst the Scheduled Tribes, the percentage of dependence on forests is on the decline in the present generation, compared to that of the two previous generations, but the dependence on agriculture and other miscellaneous professions is on the increase, if the primary and secondary professions are taken into consideration together. The percentage of dependence on forests among the Scheduled Castes is insignificant for the present generation. The trend remains the same for the last three generations, if the primary and secondary professions are taken into account. The percentage of dependence on agriculture is also the

same as that on forests for the last three generations, but the dependence on other miscellaneous professions is on the increase. The results of the survey indicate the following in respect of this North Bengal village, namely, Pump Basti of the District of Jalpaiguri :

1. Species generally used for firewood : *Dillenia indica*, *Amoora Wallichi*, *Castanopsis indica*, *Macaranga denticulata*, *Lagerstroemia speciosa*, etc.
2. Species generally used for agricultural implements : *Syzygium Cumini*, *Castanopsis indica*, *Alstonia scholaris*, *Shorea robusta*.
3. Medicinal plants used are : *Azadirachta indica* (for fever), *Aeglemermelos* (for fever), *Alstonia scholaris* (for pain in chest).
4. Plants worshipped are : *Ficus bengalensis* (Brahma regarded as God), *Ficus religiosa* (Vishnu regarded as God).
5. Plant species used for human consumption are : *Dillenia indica*, *Syzygium Cumini*, *Azadirachta indica*.
6. Fodder species are : *Macaranga denticulata*, *Dillenia indica*, *Stereospermum chelonoides*.
7. No household reported that hunting was a profession to any individual, during the last three generations, irrespective of caste.
8. Plant species used for construction of houses etc., are : *Amoora Wallichi*, *Disoxylym procerum*, *Shorea robusta*, *Dalbergia sissoo*, *Gmelina arborea*, etc.
9. If seasonal employment is taken into consideration, forestry proves to have made a very significant impact from one generation to the other, irrespective of caste. Amongst general caste, the dependency index on forestry increased by as much as 18 times for the present generation as compared to that of the past two generations. The same index increased by 16 times in respect of Scheduled Tribes. In respect of Scheduled Caste, such index percentage was 66·6 from the 'Zero' figures of the past two generations.

II

Talpukuria village of Anchal Bhulabheda No. 10 under police station Binpur of Jhargram Subdivision in Midnapore District, with a total number of 80 households, including 55 Scheduled

Tribe families, 18 Scheduled Caste families and the remaining 7 general and other caste families, (total population 439 individuals : 230 male and 209 female) reveals marginal increase of dependence on agriculture as a primary profession in the present generation as compared to that of the past two generations. The secondary profession as day-labourer has made significant impact in the present generation compared to the past two generations. The index of dependency percentage on forestry activities, had shown a sharp rise in the present generation as against the last two generations, irrespective of caste. The Scheduled Tribe, maintained a high rate of dependency throughout the three generations and the percentage rise was more pronounced in this village. The result of survey of the village is as follows :

1. Plant species generally used for firewood are : *Shorea robusta* (Sal), *Diospyros melanoxylon* (Kend), *Terminalia tomentosa* (Asan), *Holarrhena antidy senterica* (Kurchi), *Buchanania latifolia* (Pial), *Lagerstroemia Parviflora* (*Sidha*), *Cleistanthus collinus* (*Parasi*), etc.

   There is no significant variation amongst different castes so far as the use of firewood is concerned.
2. Plant species used for house construction and agricultural implements are : *Shorea robusta* (Sal), *Azadirachta indica* (Neem), *Cleistanthus collinus* (Parasi), *Madhuca latifolia* (Mohua), *Cochlospermum gosypium* (Galgali), *Pterocarpus marsupium* (Peasal), *Soymida febrifuga* (Rahara), *Schleichera trijuga* (Kusum), *Butea monosperma* (Palas), *Adina cordifolia* (*Chakalta*), *Gmelina arborea* (Gamar), *Semecarpus anacardium* (Bhela).
3. Medicinal plants used are : *Asparagus racemosus* (*Satamuli*) *Nyctanthes arbortristes* (*Senti*), *Shorea robusta* (Sal), *Terminalia chebulax* (*Haritaki*), *Phyllanthus emblica* (*Amlaki*), etc.
4. Fruit trees for human consumption include : *Diospyros melanoxilon*, *Buchanania latifolia*, *Syzygium cumini*, *Madhuca latifolia*, *Terminalia chebula*, *Semecarpus anacardium*, *Mangifera indica*, etc.
5. Plant species worshipped as village gods are : *Shorea robusta* (Sal), *Adina cordifolia* (Chakalta).
6. Fats of chicken and pig are applied for cure of rheumatism by rubbing on the affected areas of the body.

7. Scheduled tribe households took to hunting as a profession during the last three generations as 100%, 99% and 82% respectively. But not even a single family of the Scheduled caste and other general caste families took up hunting as a profession during the period of the last three generations.
8. Elephant, horse and cow are regarded as animal gods by the villagers, in general.

The impact of agriculture as a primary profession remained the same for the previous two generations, but registered an increase in the present generation. The secondary profession as wage earning labourer registered a steady rise for the last three generations ; 74%, 75% and 84.4% dependence amongst the families for the three successive generations. So, the picture of dependence on forestry activities is different in two different agroclimatic regions of the State. Forestry is coming up in a big way so far as seasonal employment is concerned in the two regions.

III

A Gosaba Village, in 24 Parganas district with 532 households (Scheduled Caste 163, Scheduled Tribes 8 and Other Caste 361) reveals interesting facts of social ecology. Among the Scheduled Tribes, the pattern tends to indicate that over the last three generations people have been showing less responses in taking up agriculture as their primary profession. While 86% of the grandfathers took up agriculture, 82% of the fathers did the same, the percentage of the present generation in taking up agriculture is only 33%. No positive trend is evinced in respect of their secondary professions. Literacy amongst women is hardly 8% and the percentage of the wage-earners amongst women is lamentably low—only about 11%. The trend of primary profession as agriculturist has also registered similar position with regard to Scheduled Castes and Scheduled Tribes. Amongst the Scheduled Castes, craze for white-collar jobs as a primary profession show a steady rise (17% for the present against 3% and 1% of the fathers and grandfathers). Agricultural day-labour and service, however, continued to be significant as secondary profession of the Scheduled Caste people. Female literacy and employment in service among females in respect of Scheduled Caste people

formed 68% and 2% respectively. Amongst the General Caste people, the trend is also interesting. While agriculture is having less responses from the generation of the grandfathers (87%), it declined among fathers (77%) and it further slipped down (64%) in the present generation. In primary profession, however, a reverse trend is noticeable in the matter of service and other employments. Agriculture, as a secondary profession, is also showing the similar trend. But the present generation is switching over to daily wage earning job of labourers as a secondary profession (63% of the present generation, 4% in respect of father and none in respect of grandfather). Female literacy and female wage earners constitute 36% and 6% respectively in the community, in respect of general caste families.

Ficusreligiosa (Baat) and Aegle marmelos (Bel) trees, are regarded as 'Shiva' and cow as 'Bhagabati' by all the communities, irrespective of caste. All the communities collect firewood from the Sundarbans mangrove forests and also supplement them with purchase from the outside markets. Scheduled Castes and Tribes are dependant more on local forest resources of Sundarbans, while general caste families consume more from outside sources for their day-to-day requirements and for making building materials etc., per capita income of the Scheduled Tribes, Scheduled Castes and General Caste is computed at Rs. 165, Rs. 123 and Rs. 107 per month, respectively.

The results of the survey of the village are as follows :

1. Species generally used for firewood : *Ceriops roxburghiana*, *Excaecaria agallocha*, *Azadirachta indica*, *Casuarina equisetifolia*, *Sonneretia apetala*, etc.
2. Species generally used for making agricultural implements : *Heritiera minor*, *Carapa moluccensis*, *Eucalyptus species*, *Casuarina equisetifolia*, *Acacia arabica*, etc.
3. Medicinal plants used are *Azadirachta indica* (for fever), *Aegle marmelos* (for fever), etc.
4. Plants worshipped are *Ficus religiosa* and *Aegle marmelos* as 'Shiva'.
5. Fruit trees for human consumption include *Diospyros melanoxilon*, *Mangifera indica*, *Sonneretia apetala*, *Azadirachta indica*, etc.

6. Plant species used for house construction : *Shorea robusta, Ceriops roxburghiana, Heritiera minor, Excaecaria agallocha, Nipa fruticans, Casuarina equisetifolia,* etc.
7. Agriculture as a profession attracts lesser number of people in the present generation than in the past ones.
8. Service as a means of wage earning is attracting more people of the present generation than those of the earlier two generations.
9. 'Tiger' and 'Cow' are regarded as gods by the communities, in general and some identify the tiger god 'Dakshin Roy' with the tiger itself.

IV

Among the three villages under study, Gosaba in 24 Parganas district and Talpukuria in Midnapore constitute a predominantly a large percentage of scheduled caste and scheduled tribes population, Pumpbasti of Jalpaiguri has a large percentage of general caste population in the aggregate, but not substantially larger than scheduled tribe population. The villages are alike in terms of caste character.

Table 6 : 1

NUMBER OF HOUSEHOLDS

Name of Village	*SC*	%	*ST*	%	*C*	%	*Total*
1	2	3	4	5	6	7	8
Gosaba	163	30	8	2	361	68	532
Pumpbasti	3	8.3	16	44.4	17	47.3	36
Talpukuria	18	22.5	55	69	7	8.5	80

SC : Schedule Caste
ST : Schedule Tribe
C : Other Castes

Table 6 : 2

SEX-WISE LABOUR AND NON-LABOUR FORCE IN SAMPLE VILLAGES

Name of Village	*Non-labour force (below 14 yrs. of age)*			*Labour force (above 14 yrs. of age)*			*Total population of village*	*Percentage of non-labour force in village*	*Percentage of labour force in village*
	Male	*Female*	*Total*	*Male*	*Female*	*Total*			
1	2	3	4	5	6	7	8	9	10
Gosaba	549	525	1074	827	691	1518	2592	41	59
Pumpasti	48	60	108	50	42	92	200	54	46
Talpukuria	88	98	186	142	111	253	439	42	58

Table 6 : 3

POPULATION OF SAMPLE VILLAGES

Name of Villages	*Male*	%	*Female*	%	*Total*
1	2	3	4	5	6
Gosaba	1376	53.09	1216	46.91	2592
Pump basti	98	49.00	102	51.00	200
Talpukuria	230	52.00	209	48.00	439

Gosaba and Talpukuria have more number of male members than the female members, while Pumpbasti has more number of female members than male members.

In Gosaba and Talpukuria, the percentage of labour force is more than that of non-labour force—about 18% and 16% respectively ; while in the case of Pumpbasti, the percentage of non-labour force is 8% more than the labour force.

Table 6 : 4

LITERACY

Name of Village	*Male*	%	*Female*	%	*Total*
1	2	3	4	5	6
Gosaba	830	64.74	452	35.26	1282
Pumpbasti	42	76.00	13	24.00	55
Talpukuria	135	73.00	49	27.00	184

In all the three villages the percentage of literacy among males is more than that among the females and the extent of difference in percentages in villages Gosaba, Pumpbasti and Talpukuria constitute 28.48, 52 and 46 respectively.

7

Phases of Symbiotic Relationship

Forests, regarded often as the splendid manifestation of plant life on earth, have played a very significant role in the development of human resources, providing for all the basic needs of human life, viz., timber for building construction and furniture making, fuel for fire, foodstuffs, clothes and medicinal plants to fight against discomforts and diseases and, last but not the least, the ecosystem which is vitally necessary for the survival of the homo sapiens.

But what is the condition of such benevolent forests now ? The man for whom the trees are doing and can do so much are now being recklessly cut for meeting industrial and commercial needs. Men are often unaware of the evil effects of many of their supposedly development activities which impinge deeply and yet silently on the animate and inanimate environments. Much of man's life is spent in places greatly altered by human interference, e.g., cities, towns, villages, railway communications, road-links, fields and orchards and all the concomitant comforts and amenities accruing thereto. These surroundings tend to blur our vision about what is happening beyond, i.e., in the areas where non-human forces still hold their sway.

Unimaginable forces had been at work to shape the terrestrial scene for thousands of years, before man learnt to tamper drastically with the surface of the earth. Human abuses and assaults on nature had been brilliantly set forth in Rachel Carson's monumental book 'Silent Spring'. The first two paragraphs of the second Chapter, entitled—'The obligation to Endure'—of the said book clearly bring out the range of human abuses on nature :

'The history of life on earth has been a history of interaction between living things and their surroundings. To a large extent,

the physical form and the habits of the earth's vegetation and its animal life have been moulded by the environment. Considering the whole span of earthly time, the opposite effect, in which life actually modifies its surroundings, has been relatively slight. Only within the moment of time represented by the present century has one species—Man—acquired significant power to alter the nature of his world. During the past quarter century this power has not only increased to one of disturbing magnitude but it has changed in character. The most alarming of all man's assaults upon the environment is the contamination of air, earth, rivers and sea with dangerous and even lethal materials. This pollution is for the most part irrecoverable ; the chain of evil it initiates, not only in the world that must support life but also in living tissues, is for the most part irreversible. In this present-day universal contamination of the environment, chemicals are the sinister and little-recognised partners of radiation in changing the very nature of the world, the very nature of its life.'

II

Of all the innumerable living beings on earth, man has made the deepest impact on his environments. He has brought about changes of gigantic magnitude and diversities. All other living beings, in absence of human confrontation, have worked as a partner to a complex and relatively stable formation, each having had developed into, what is now popularly termed, as a climax community, i.e., the highest type that is determined by the nature of soil and climate obtaining there. Sans human interference, the climax forest is the result of adjustment and needle-fine balance achieved through long periods (covering millions of years) of competition between the contending animals and plant-components of the forest. Beside animal communities, insects play an extremely important, almost predominant, role.

But in the ultimate analysis, a delicate balance is struck between the various elements—a balance maintained by countless stresses and strains, thrusts and counter-thrusts between predators and prey organisms. Any breaking of these individual threads may lead to drastic alteration of the astonishingly complicated fabric of the ecosystem. Man has actually appeared on the natural scene as a super-predator, always interacting with

other living oragnisms for the so-called benefit of their race, but that interaction was proved to be the most baneful and corroding effects on the human society. Being unmindful to the intricate natural balance and being led by careless and selfish motives, man tries to build an empire in which he becomes a panjandrum. Man interacts in the natural process by large-scale exploitation, felling of trees and removal of plants, destruction of innocent wild denizens for food, for satiating lust and adventure. This had set in a chain reaction of soil erosion, air and water pollution and ultimately cause irreparable damage to the living conditions of man himself ; he is entrapped by the evil effects of his own doings. This human interference also runs counter to the useful natural processes, like keeping a balance in carbon and nitrogen cycles. The mighty human interference caused harmful effects on the natural processes of food chains. All these, so to say, are exercises in futility by man. Such disturbance in nature is baneful because of the removal of any stage of individual in the Pyramidal structure of the community of living organisms which is deleterious to the harmonious functioning of the structure. An example of such imbalance in the relationship can be found between plant community, deer and tiger population in their natural setting. It is a matter of common knowledge that if tigers are killed, there will be a disproportionate growth in the number of deer population with the consequent exhaustion of grasslands ; or the deer may even come to devour the forest seedlings.

III

The imbalance in nature is caused also from the defective logging techniques of trees. Cuttings of only the choice trees and felling of some plant species excessively have denuded the forest and exposed them to the attacks of insects and vermins due to the changed stand composition. Defoliation became more prominent and killed thousands of trees before the stand composition restricted further population growth of the pests and insects.

The use of sprays, raging of forest fires and drastic alteration of the forest composition of disease-resistant natural stands of mixed species of trees, i.e., the human machinations, have caused

irreparable damage to the habitats of beneficial and beautiful birds, animals and insects which have been helping to keep the natural balance for the sustenance of human race. The result is simply disastrous. Trees are attacked with parasites or vermins, as in the case of pure plantations of *Gamar* (*Gmelina arborea*) ; some pure *Gamar* plantations have been killed by Loranthus infestation, some suffer badly year after year from defoliation by the beetle *Calopepla leayana*. Attacks from insects cause severe damage to pure plantations of Teak (Tectona grandis) from *Cedrela toona*, from root and shoot borer, *Hypsipyla robusta*, Semal (*Bombax malabaricum*), from *Tonica niviferana*, and similar is the case with other plant species. Another severe damage is done by the baneful effects of shifting cultivation—an example of grave human abuse of nature. This had not only caused soil degeneration due to impoverishment of soil regime, but it also degrades the animal-vegetation matrix of the forest. Lateritic belts of West Bengal bear eloquent testimony to human greed, carelessness and laboured abuses. Here, prolonged regime of intentional or unintentional fire, unrestricted grazing and short coppice rotations of 5 to 8 years have given rise to bare and barren land called 'danga' on the one hand, and stunted growth of crops as well as diseased *Sal* (*Shorea robusta*) trees on the other. The human abuses in the area have resulted in incurable infections of *Sal* trees with the heart-rot fungus (*Fomes* species).

IV

Destruction of trees and continued depletion of plant-and-animal life are caused by carelessness of the local people. Maintenance of groves as a sacred thing is an ancient custom amongst the tribals. Tree-worship as a part of their ritual, the tribal people used to revere and protect the groves as the dwelling places of tribal-gods. Felling, lopping or damaging trees therein was a taboo. In the districts of Purulia, Bankura, Midnapore, Burdwan and Birbhum existence of some of the sacred groves of *Sal*, *Bot*, *Mahua* trees, etc., still bear testimony to these traditional practices. In some of the villages, only these sacred groves mark a sharp contrast to the otherwise barren, laterite and vacant 'danga' lands.

The time-honoured tradition and what was ridiculed as superstition of the tribal people to the maintenance of sacred groves are on the wane with spread of Christianity, as was noticed in many parts of West Bengal. This iconoclastic attitude of the Christian converts wanted to bring about a change in the tradition, customs, attitude and life-style of the villagers, particularly among the tribals. While dwelling on the baneful effects of religious conversions, N. L. Bor said in his note captioned 'The Relict Vegetation of the Shillong Plateau, Assam (Indian Forest Records, New Series, Botany Vol. III, No. 6 : January, 1942)' the following :

'...Missionaries have been at work in these hills now for many years and the so-called superstition has begun to wane. It has always been a matter of great regret to me that the spread of Christianity in the hills tend to involve the complete destruction of all that is most interesting in the lives and customs of primitive peoples...a student of vegetation cannot observe the destruction of forest which has taken thousands of years to reach its full expression, without some feeling of irritation.'

'...the converted Khasi thinks it is a splendid thing to go into a sacred grove and cut a tree in order to defy the gods of his fathers and show his pagan brothers that their beliefs are all wrong.'

V

Everywhere man involves himself in a ceaseless attempt to mould the environment to his advantage often in a simplistic manner, when he establishes large tracts of culture of one plant species or mono-culture of either agricultural or forest crop, or he reduces a complex natural formation with the aid of fire, axe and cattle to grassland. Worse still, he has allowed his cattle to overgraze and set in motion a serious process of erosion, ending in gullies and ravines. His activities result more often than not in negation of complexity and, in many instances, in abdication of life itself. For meeting the commercial and industrial needs and avocations sometimes a wedge is driven into the inherent natural ecosystem of plant and animal, resulting in human misery. Vast areas of man-made deserts and ravines, mountain-side avalanches and once-fertile flood ravaged plains rendered

sterile are the vivid expressions of human carelessness and disuses.

One of the foremost ecologists, Charles S. Elton, in his last chapter entitled 'The Conservation of Variety'. 'Ecology of invasions by Animals and Plants' :

'...At some future date mankind is likely to look back upon the present-day efforts of mass-destruction as we now do upon the mistakes of the industrial age, the excesses of colonial exploitation, and the indiscriminate felling of climax forests.'

Charles Darwin had prophetically told that in many places the soil, plants and animals which form the environment of man had '...reached a natural balance which man disturbs at his peril'.

It is high time that man gave due credence to the time-honoured concepts of ecology that the forces set in motion by every act of individual animal, plant, bacterium or other living organism exert a profound influence on the lives of other fellow creatures. It would be interesting to uncover the hidden secrets of natural ecosystem as to how nature intends to maintain harmony in her richly variegated and highly colourful but continually fretful household, which always tends to drift towards disruption and disunity.

VI

People have ruthlessly plundered the priceless resources of the forest for their necessity of timber, fuel and fodder. Large forest areas have been cleared to supply fresh land for various purposes. This has, in places, changed the micro and macro-climatic conditions and has increased soil erosion to lead to siltation of our dams and reservoirs, removal of fertile top-soil, creation of floods and draughts. All this requires a lot of money to mend now.

Examples of human onslaught on nature can be found in North and South West Bengal as also in the Sundarbans delta. Gradual encroachment on the previously uninhabited areas in search of more and more land for marginal cultivation and establishment of new settlements is destroying, sometimes irrecoverably, valuable heritage of wildlife (both flora and fauna species) and converting diversified places of scenic beauty into

lands of charred and arid monotony that we generally come across in cities and towns.

There is, however, no gainsaying the fact that wild species of plants and animals have been nursed and nurtured by man for their domestication or growing of crops and ornamentation with flower plants. He has been trying to collect many life-sustaining products from the forests. Wild animals in forests have provided an added attraction to the tourists and they have become a perennial source of foreign exchange income. Birds also have tremendous economic and ecological value in maintaining balance of nature by eating up the pests, insects and vermins that cause damage to plants and crops. The birds of prey and the snakes control rodent population that devour agricultural crops. Trees and other vegetational tiers in the matrix help produce life-sustaining oxygen and prevent soil erosion, conserve water and purifies air. For all this, unplanned felling of trees, barking them for fuel and fodder, careless disposal of garbage near them, creation of insanitary conditon, are the kinds of human abuses that produce baneful effects on the natural growth processes.

VII

Nature is more powerful than man. Nothing on this earth can survive in continuous conflict with nature. The existence of human race as a whole is dependent on learning to live in harmony with the nature. The physical nature outside controls man's nature within him and it is the man's own nature that brings disaster. So, it is important to preserve harmony with nature as the first step. If developmental programmes are taken up in hurry with utter disregard of environment these will produce adverse effect on the ecosystem. The objectives of development without destruction should be the be-all and end-all of any such exercise. It will not be out of place to quote some excerpts from the findings of one of the most scholastic studies conducted by the Committee on Environmental Quality set up by the United States. The Committee summed up their views as follows : According to Pal, B. P.

'Environment, resource and population stresses are intensifying and will increasingly determine the quality of human life

on planet. These stresses are already severe enough to deny many millions of people basic needs for food, shelter, health and jobs, of any hope for betterment. At the same time, the earth's carrying capacity—the ability of biological systems to provide resources for human needs—is eroding.'

The above statement is *ipso-facto* applicable to the State of West Bangal, which is endowed with vast natural resources but which, in course of history, becomes an object of exploitation to the people subsisting on the marginal level of existence and have no other means than to take to croplands, grazing lands and fuel wherever they can lay their hands on. The provision of basic human needs must, therefore, be the bedrock of economic upliftment. But such process of development should be closely linked with the environmental protection and management of natural resources of which plant and animal resources form an integral and inseparable part.

VIII

It is a matter of immense distress that vast stretches of precious forests in the State of West Bengal are being cleared up to make room for the advancing agriculture ; even mountain slopes which, according to the tenets of land-use planning and capability, are fit only for grassland or forestry, have been brought under plough, resulting in large-scale soil erosion, drying up of water reservoirs and other deleterious upshots. So, the planning processes should be so geared as to create optimum condition for the growth of plant and animal community at large through a balanced and complementary land-use policy.

Another important aspect of agriculture of great concern is the large but unproductive and unhealthy livestock population in the State. As per Livestock Census Report, 1976, the total number of cattle, including buffaloes, is 12.7 millions or, in other words, 3 cattle per head and 132 heads of cattle per square kilometre of the geographical area of the State. This is considered to be far in excess over the 'carrying capacity' of the land area. No wonder, therefore, that they do more harm than good to the soil and to the vegetal cover, and are largely instrumental to the degradation of the environment and soil. This clearly indicates that an integrated policy with appropriate guidelines and suitable

infrastructures should be adopted to control and regulate the animal population. In order to arrest the evil of denudation of forests arising out of the constant pressure for more arable land, a suitable and coherent policy can be evolved to increase not only the existing cultivable land but also provide gainful employment to people in non-agricultural avocations. A balance has to be struck between agriculture and forestry in order to benefit both the sectors for the ultimate welfare of the people of the State.

IX

Another major zone of human interaction with plant and animal is soil conservation. This can never be considered separately from water. Water is an inescapable necessity of life. If water is wasted, it will not only cause hardships to the living beings for want of it, but it may also cause tremendous damage to the soil. It is a matter of common experience that in major dams and irrigation schemes, apart from the soil damage caused by seepage, siltation and salinisation set in. Such a condition is fraught with danger of increasing growth of agricultural pests and diseases. The insect-pest complex may also undergo change particularly where the drainage and water management systems are not equally good. Ecologically, forests and the associated vegetation cover help break the force of heavy rain and allow it to percolate gently into the pores of soil where it re-charges the natural springs and reservoirs. In absence of forest, large-scale pollution of soil, water and air will increase. It will further increase the incidence of land-slides, silting up of river-beds and occurrence of flood in the plains below. With the loss of forest, farmers will be hard put to find fuel and firewood that serve them as the means of cooking and also used for other domestic purposes ; and they will be under the painful necessity to burn dried cowdung cakes, depriving the soil of much-needed cheap manure.

X

In order to determine the pattern of supply, demand and consumption of wood and wood-products in West Bengal, a

wood-balance study was carried out with a stratified random sampling design. For this purpose, the State of West Bengal was divided into urban and rural sectors. There are, in all, 38,074 villages and 15,685 urban census blocks in the State. A 2-per cent and 5-per cent sampling fractions in rural and urban sectors respectively were employed. This involved survey of 760 villages and about 750 urban census blocks by enumerators. Then, 5 households and 10 households respectively were again chosen at random in each sample village and urban census blocks, while all the wood consuming institutions were surveyed. Enumerators were employed to record all relevant information of wood demand and consumption. All the particulars of fuel wood, timber, fodder consumptions were noted after necessary investigation by the enumerators in the specially designed registers. All districts of the State were covered in this way.

XI

The wood-balance study has yielded revealing information. While the total supply of wood, including fuel and timber, in the State of West Bengal has been about 1 million cubic metres, the actual amount of consumption is found to be in the vicinity of 17 million cubic metres. This means that the actual wood consumption is 17 times more than the total supply of wood from the State-owned forests. Per capita rate of consumption also varies from district to district. While it is more in the forested districts of the State, it is less in the non-forested districts. The table below (7 : 1) makes the position clear :

Table 7 : 1

ANNUAL PER CAPITA CONSUMPTION OF WOOD

Name of District	*In Cubic Metre*
Darjeeling	1.103
Jalpaiguri	0.519
Cooch Behar	0.364
Burdwan	0.118
Birbhum	0.367

Name of District	*In Cubic Metre*
Hooghly	0.119
Nadia	0.233
Midnapore	0.531
24-Parganas	0.257
Howrah	0.147
Murshidabad	0.221
West Dinajpore	0.176
Malda	0.212
Bankura	0.413
Purulia	0.435
Calcutta	0.017
	0.288 (State average)

The above table shows the staggering consumption of wood and wood-products. The disparity between supply and consumption has given rise to clandestine lifting of forest produce from the Government forests and consequently to man-forest interaction. This inter-relationship among man, plant and animal needs to be viewed against the backdrop of the awe-inspiring and ever-widening hiatus of demand and supply of wood and wood-products in the State. The shortfall in wood supply is obviously met partly by its procurement from non-Government sources of wood, partly by imports from other State resources and, last but not the least, by clandestine lifting from Government forests. Planners should, therefore, examine the question of feasibility of creating alternative sources of supply with a view to minimising the wood consumption pattern. This may improve the conditions of forest protection. It would be worthwhile to ascertain whether the gaps between supply and demand of wood and wood-products would give rise to any chain reaction in markets and encourage exploitation of consumers. Substitutes to wood and wood-products can also be possibly found out.

XII

Sengupta, Sankar (1976, 1980) Bagchi, Dipika (1960), Bose, Nirmal (1972), Collis, John (1950) and Bhowmick, P. K. (1978), etc., had dwelt on man-plant-animal interactions.

In the Hindu *Puranas* it is stated that before starting the churning of the ocean of milk at the behest of Lord Vishnu, the Gods and the Demons placed all the medicinal herbs in the ocean. Towards the end of their effort, God Dhanyantari appeared before them with a pot of 'Amrita' (necter) in quest of which the Lords and the Demons were engaged in churning the ocean of milk. The 'Amrita', it may be mentioned, is the essence of medicinal herbs which, if taken, brings immunity from disease and death. Thus, it implies that herbs only can cure indisposition. In the Ramayana, the Rakshyasa king Ravana, who forcibly carried away Sita, the loving consort of Rama, to his capital Lanka, kept her confined under the *Saraca* (Asoka) tree. So, plant worship has its origin in history and religion also.

Today remarkable progress of science in various branches has made everything look within man's reach. Yet plants provide life-saving medicinal aids to millions of rural people. Not only this. The plants also are instrumental to providing food to men, e.g., some roots and tubers are boiled, cooked or ground into flour out of which hand-made breads or soups are prepared. Leaves also form part of edible vegetables for men. Tribal people boil certain jungle leaves along with millet or rice and devour them. Many such people living in far off places are to cover long distances to procure foodstuffs. These roots, tubers and leaves are therefore considered by them as Godsent, as they get these whenever they want. The flowers of *Argemone Medicono*, a common weed found on waste lands, are used for healing wounds and sores. Leper patients take these for recovery of their ulcers. The oil from its seeds can be used as a substitute for kerosene. The plant also provides good fuel wood. Another plant, *Tridax procubens* (Bisalyakarani), is used as a coagulent and antiseptic. Juice of the plant named *Alco barbadensis* is used for recovery from burns, skin eruptions and as remedy to heart diseases.

Plants enable men to get the essential necessities of life, viz., shelter, food, clothes, medicine, etc. Conservation of trees and

plants has been an integral part of the ecosystem. Trees are so inextricably woven in the texture of human life style that they cannot be forgotten at any stage of their life. *Azadirachta indica* (Neem) has vast medicinal properties for all types of skin diseases and blood impurities. It is believed by many that this plant wards off evil spirits ; mosquitoes and other pests can be destroyed by its use. The tree called *Ficus bengalensis* (Banyan) not only gives enjoyment to village children who love to swing on its branches, serials or prop-roots but also provides suitable habitat for avifauna. The latex of this tree is used as an aphrodisiac, as claimed by some scientists. The tree *Acacia nilotica* (Babul) is an ideal wind-breaker in the catchment areas. The powder made of the charcoal from the bark of this tree, when mixed with salt, is an excellent antidote for gum and stomach troubles. The leaves and pulp of *Aegle marmelos* (Bel) have rich medicinal properties to prevent indigestion, loss of appetite, etc. In fact, an Allopathy medicine named Quinobel is made out of the powdery bark of this tree. *Ficus religiosa* is another tree which is traditionally worshipped by the people. Its name has found place in the Vedas. Bark of another plant called *Cratava religiosa* (Baruna) is used for curing peptic ulcer and has an excellent curative value for other diseases. The tree named *Phyllanthus emblica* (Amla) has the highest Vitamin 'C' content in comparison to other plants. It is taken religiously by the people and is a good recipe for old-age ailments. It prevents toxicity —a phenomenon germane to senility. Valuable information about plants and their uses is available in the Rigveda and the Ayurveda. The story of evolution of Indian medical tradition from religious practices concerning trees and plants makes interesting reading. Man has tried to unravel the mysteries of nature. He first came across a plant the use of which alleviated physical pain. This brought him much nearer the plants and encouraged him to look closer into their beneficial effects. In the *Purana* as well as in the two great epics, remedial values of trees and plants have been mentioned. The smell of Bisalyakarani could bring life to seemingly dead Lakshmana in the Rama-Ravana war. The supposedly divine qualities in herbs drew people to worship trees and plants as also to use them on a large scale for such purposes. The two Ashwini gods were the heavenly medicine men. They prepared medicines to cure leprosy,

performed operations, gave artificial limbs and even transplanted animal head for human one. They possessed vast knowledge about plants with medicinal properties.

XIII

Certain trees continue to be worshipped in different parts of India. The village 'Guni' or exorcists still use a bunch of *Azadirachta* (Neem) leaves for fanning to drive away evil spirits. The men of yore had good idea about the properties of therapeutic value of the *Neem* plant. The leaves of *Mangifera indica* and *Cocos nucifera* are still inescapable necessities in the religious rites and rituals. Similarly, aromatic leaves of *Aegle marmelos* are indispensable in religious exercises. Again, the aromatic leaves of *Aegle marmelos* are very much in use for worship, just as those of *Azadirachta*, *Mangifera* and *Ficus species*. The leaves of the grass called *Cynodon dactylon* are required for the same purpose. Its leaves are immersed in water and given to the devotees as 'Prasad'. The juice of the leaf is astringent. People regard *Ficus religiosa* (Aswatha) tree as the abode of the 'trinity' gods of the Hindu mythology. The aromatic shrub of *Ocimum sanctum* (Tulsi) is worshipped daily by the Hindus. During the worship, the Tulsi leaves are immersed in water and taken by the devotees at the end of the Puja. Its leaves are strong expectorant.

Trees called *Thevetia Peruviana* and *Nyctanthes arbortristis* are worshipped by the Hindus, in general, not only for their religious efficacy but also for their medicinal and other properties. A group of people called 'Bishnois', in Marwar of Rajasthan State, had laid down their lives for the protection of *Prosopis Spicigera*. This is an well-known story. The 'Chipko' movement for saving forest trees, which started spontaneously in the hill areas of Uttar Pradesh, is an instance of what public awareness can do. Trees like *Shorea robusta* Bassia Latifolia, *Azadirachta indica*, *Saraca indica*, etc., are still held in high esteem by some sections of tribals and others. In villages, solitary groves of these species still stand like sentinels in the midst of reckless destruction of forests. It speaks volumes about love, devotion and reverance of the villagers for trees.

XIV

Forests, have suffered in the past, not only through human agency, but also from such natural causes as volcanic eruptions of great intensity, which tended to change the face of a country, floods, fires, and also through occasional meteoric showers. But man has undoubtedly the greatest responsibility in this regard. Yet, man has proved himself to be grave menace to the very existence of forests. History supports it that in India this ruthless and relentless destruction of forests began with the settlement of the Chalcolithic people during the period from 3500 B.C. to 3000 B.C., approximately. The forest-dwellers were the descendents of the so-called Proto-Autraloids or Austro-Asiatic people who had come to this country in some hoary past and are now represented by the Kols, the Mundas, the Birhors, the Santals, the Savaras, the Hos, the Juangs, the Karkus and the Korwars. In the *Rigveda*, they have been mentioned in various ways.

As regards their social and economic life or the profession they followed, no definite information is available, but some Vedic and Pali works unmistakably throw some light on them. It is known that they were divided into a number of clans, all belonging to totemistic origin. Thus we hear of the goat-clan (Ajas), the Fish-clan (Vayamisis), the Myenaclan (Tarakshas), the Serpent-clan (Nagas), the Hawk-clan (Kulingas), the Rabbit-clan (Lambakarnas), etc. Such totemistic people are in existence even today. Regarding their economic pursuits, it may be stated that some of them used to kill wild animals for their skins. These people even collected carcasses of dead animals in the forests for the same purpose. They used to sell these skins at a throw-away price in the jungle to eke out their livelihood. In later periods, their descendents had been mentioned in the literatures as the Charmakars or leather-workers. It is on record that the so-called Aryans compelled them to reside outside their settlements because of their disagreeable nature of job (Ashtadhyayi of Panini). Some of them, again, used to collect tusks, horns and honey-combs from the forests and sell them in the local markets, while others killed deer and sold venison, eating of which was not a taboo to the Aryans. They also sold the deer-skins. They had cut the trees in forests and sold the wood for use as fuel and other domestic purposes.

XV

It is known from 'Pali' literature that long before the sixth century B.C. the descendents of the forest-dwellers were divided into a number of professional castes, based on their forest products. They were :

1. Nalakaras or the Rush workers
2. Usukaras or the Fletchers
3. Charmakaras or the leather workers
4. Tachchhakas or Vaddhakis or the Carpenters
5. Pasikas or the Trappers (also Hunters) ; and
6. Dantakaras or the Ivory workers.

The rush workers manufactured baskets and boxes for storing articles, as also wicker stools and mattresses of different sorts. They collected canes and bamboos from the forests which were their only source of supply of raw materials. Their cottage industry was seemingly in a boom. The fletchers specialised in the manufacture of arrows made of cane tipped with iron spikes. The leather workers prepared sandals and trappings for horses for riding or drawing chariots. They also manufactured leather water-containers (Bhustra) and shields from the hides for use in warfare. Leather straps needed by the hunters were also used to be supplied by them cow-hides and buffalo-hides were purchased by them from local markets, while the skins of wild animals were collected from the forests. The carpenters (Tachchhaka ; Vaddhaki) made doors and windows as well as poles and rafters needed as materials for building cottages. They were also Cabvriet-makers and builders of wooden houses. They made carts and chariots as also wheels needed by potters. They manufactured wooden sandals mostly used by the Aryans. The greatest dependence was on the forests, considering the things made by them. The trappers, who were also the hunters, used to trap wild animals, either for skin or for flesh. In Pali literature they are mentioned as the *Nisadas* and *Pasikas* (from pasa or strap). They trapped wild boars, rabbits, deer, etc., killed them and sold the flesh in local markets. The profession of ivory workers was undoubtedly lucrative. It is belived that for supply of ivory, they depended only on the hunters and the trappers. Besides the members of the totemistic clans, mentioned earlier, who were regular forest-dwellers and depended entirely on the

forest products as their only means of subsistence, there were also others who took shelter in the forests. They were dacoits, robbers and murderers whose names had been written on the king's porch, along with the royal order as : '...whenever they would be found, they should be killed' (Vinayya-Pitaka. H. Oldenberg). The dacoits, robbers often attacked the merchants who crossed the forests with their bullock carts loaded with merchandise, and plundered them.

Evidence is available from the Rig Veda and other Vedic literatures that the Aryans were careful observers of flora and fauna—a fact which goes long way to show that they were a cultured race. After migration, they began to study forest potentialities and thought of proper utilisation. They located and preserved the medicinal plants, shrubs and herbs. In respect of the forests, their main task was to sort out the fruit trees, flowering trees and the trees which could be used either as firewood or timber. They also knew that the best collection of the medicinal plants (Oushadhi) should be made when the Venus (Oushadhi-Taraka) would be shining in the Eastern Sky before sunrise. They believed that medicinal plants were most effective during that period, a fact later admitted by botanists. The totemistic clans of the Ganges valley, which mostly dwelt inside the forests, contributed in no small measure to the knowledge of Indian plants already acquired by the Aryans. The Aryans initially dubbed them as the *Dasas* (Slaves), but about the time when the tenth *Mandala* of the *Rig Veda* was composed, they were called 'Sudras' and admitted within the pale of the Aryan society. The period of that *Mandala* is fixed not later then 1500 B.C. The Aryans learnt quite a lot from those 'Sudras' regarding the poisonous and non-poisonous plants. The 'Vanaprastha' system of Aryans also helped them to study the plants and mysticism. In the *Rig Veda*, mention is made of flowers, seeds, roots, fruits, etc., as useful drugs, named as 'Oushadhis'.

XVI

Forests and their dwellers, were subjected to administrative control gradually with the passage of time. The Forest Department did not have any separate existence prior to 321 B.C. which synchronised with the foundation of the Maurya Empire. The

existence of the then Forest Department, as mentioned in the *Arthasastra* of Kautilya, was in a kingdom and not in an empire. Specific duties were allotted to the Adhyakshas Vanapalas of Forest Department as specified in the *Arthasastra* for increasing the production of forest produce, preservation of flora and fauna and some other odd jobs. The idea of Reserve Forests was perhaps first thought by Emperor Asoka (B.C. 269—B.C. 227). Three classes of forests were specified in the *Arthashastra*, i.e.,

1. The Reserve Forests,
2. Forests donated to eminent Brahmans, and
3. Forests for the public, which could only be used for hunting purposes.

Maurya rulers considered afforestation to be essentially necessary in the interest of the State. Some Forest Laws and Game Laws were in vogue during the Mauryan Empire, as mentioned in the *Arthashastra*. The interest of forest management was strengthened further during the Gupta period. Available literary evidence suggests the existence of a Silviculture Department under a Superintendent to look after the different aspects of soil, on the same lines as the modern Forest Department. A striking similarity is noticed between the ancient and the modern methods of forest divisions into Ranges, Beats, etc. Despite the existence of forest regulations, forests have been disappearing gradually. Forest tracts, big or small, referred to in the FO-KWO-Ki of Fa-hien, in the Si-Yu-Ki of Yuan-chwang or even in the Periplus Marix Erythral of anonymous authorship, have mostly disappeared. The Hindu rulers (1000 to 1200 A.D.), were as much responsible as their Muslim successors. In the Medieval period of Indian History, 'forestry' was a neglected economic institution. The primitive men worshipped nature and tried to gain control over nature from within did little damage to it. They believed nature was the giver of the means of livelihood and should be worshipped. The modern man, armed with the power of science and technology, arrogates omnipotence to himself. He is 'so aware of his strength that he is unaware of its weakness' especially in the matter of use of natural resources. In his strides to satisfying some of their needs and aspirations, men have also created certain insurmountable problems through improper application of science and technology, and penalty for which has to be paid at the expense of damage or destruction to natural

environment, a precious heritage which once lost is lost forever. In the Isho-Ponishad, there is an apt statement saying, 'This Universe is the creation of the Supreme Power meant for the benefit to all His creations. Individual species must therefore learn to enjoy its benefits by forming a part of the system in close relation with other species. Let not only one species encroach upon the other's rights'. This is true in every age.

XVII

From the beginning of life, trees have been looked upon by man with love and reverence. Man began to worship tree taking it as an abode of god or supernatural power. Thus tree worship began before the dawn of history. Ritualistic veneration of trees as a practice became widespread. Some scholars have compared the Hebrew words for 'god' (EL) with words for 'tree' (elah).

Sengupta, Sankar (1976 and 1980) had dwelt on aspects of folk-lore and tree worship from the socio-folklorological points of view.

In India, tree worship is universal. Various trees, plants and groves are worshipped by people of different class, caste, community. 'Soma' (sacrosttemma acidum or S. breviot-gma) was considered as tree of life by the Vedic Aryans, Vata, Asvatha, Bel, Tulsi, etc., are the dwelling places of the Hindu gods Brahma, Vishnu, Maheswara, Krishna. Lord Buddha attained Nirvana under a Pipul tree. In the seventh heaven of the Holy Koran, beside the throne of god stands a sacred tree, beyond which even Mohammed was not allowed to pass. The performing rites or procedures and purposes of tree worship, have not much changed. But environmental changes have brought about large modification in concept. The cult of tree is a symbolic representation. It is not merely a ritual activity. It includes the beliefs, superstitions and myths centering round rites. When tree symbol is used for a Hindu god or a goddess it is considered sacred. Often this symbol is alive with religious meaning and powers. The images, trees and stones symbolise the various attributes of god. It is the divine spirit which is worshipped in them.

According to the Upanishada, 'the god who exists in this Universe, in water, in fire also exists in large trees and herbs'. The Hindus worship tree as god but not god as tree. According to Sankar Sengupta, tree worship is of two categories (i) the tree-god whose worship became organised into a definite religion and (ii) tree-spirits whose propitiation degraded the level of sorcery and incantation. Magic and all that were supernatural were ascribed to the trees. The utilitarian role of trees has been the main concern of modern men.

8

Conclusion

Plants and animals complement each other in the ecosystem. They interact with each other in a finely balanced fulcrum. Destruction of one sets in a chain-reaction the accumulated result of which destroys the balance and the system irreversibly. In the area under study in West Bengal, such imbalance was caused by large-scale cutting and felling of trees, destroying vegetal cover, killing of wild denizens of the forests, largely for meeting ever expanding human needs and also for economic gains, sports and adventures. As a result, there is environmental pollution, soil erosion, landslides and a host of calamities. While man is the most affected by his impudence and ruthless activity, it is he who can save the balance and the system from destruction.

The study aimed to find out the existence of a triangular relationship ideally balanced among men, plants and animals in a particular ecological setting and how this balance was open to disruption by supposed developmental activities undertaken over the years. Man is the prime mover in the ecosystem, and whatever he does can make or unmake the entire system. If the ecosystem is disrupted the man is most intensely affected. Yet, he alone can save the system from wanton destruction, because he has the knowledge of this triangular relationship, he can manipulate, he can control his own nature within, in addition to controlling nature outside. He can build a new environment, tent hardly he can ever ignore the triangular relationship.

The evolution of Indian forests through the ages presents interesting lessons. A single plant appearing about 440 to 480 million years from now had grown into several hundreds of

genera and several thousands of species in the course of one hundred million years.

India had lost forests covering an area of about 41357 square km between 1951 and 1976, for developmental reasons, like river valley projects, agriculture, road construction, industrial development, and other miscellaneous purposes. The signs of ravages had naturally engulfed the State of West Bengal whose per capita forest area was .02 hectare, a figure very low in comparison with the all-India average of .12 hectare and world average of 1.0 hectare. Forests of West Bengal bear the scars of ecological ravages in its worst form.

The forest policy and administration could not save the forests from being denuded. Efforts were not wholehearted, nor it was easy to withstand the pressure on land because of the expanding population. Every Government opted the easy way. The forest area is about 20% of the cultivated area, yet the contribution of the forestry sector to the net domestic product is insignificant in this State.

The National Forest Policy of 1894 led the establishment and growth of tea estates in North Bengal hills and plains of Duars, large-scale clearance of forests by migrated population from Nepal expansion of transport resulted in the inroads of natural forest resources and disappearance of indigeneous population due to import of cheap labour from outside. The policy did more harm than good as forests were cleared more and more for the so-called developmental activities of the State. The policy of 1952, classified the forest areas on a functional basis and emphasised the need for balanced and complementary land-use under each type of forests. But what was professed to be practised and what was actually done were miles apart. There was no concerted effort to bring the recommended 60% of area under forests in the hills and 20% in the plains.

The exploitation of forest resources for the benefit of the present and future generations has to be sustained on a harmonious relationship between man and nature. There has to be a method in the exploitation of forest resources without the natural balance being disturbed. It is here that the failure has occurred. The study in Sundarbans mangroves inhabit higher caloric concentrations and record significantly high bio-mass productivity with low generic and specific diversity, generally both for flora and

fauna. The balance of poor floral and faunal diversity in Sundarbans mangroves is partically compensated by lesser biotic interference. So, with proper forest management, Sundarbans holds bright future for a natural ecosystem.

Within a particular ecosystem, the generic diversity maintains a positive correlation with specific diversity which is of paramount importance for evolution of a particular ecosystem. Many medicinal, decorative and economically important plants have been endangered due to overuse and unrestricted exploitation. It is necessary to cultivate and conserve these plants.

Generic and specific diversity records both flora and fauna. The parallelism in the vegetational diversity-increase and increase in animal-population is noticed as a matter of immense bio-ecological importance. A very low generic and specific diversity warrant the necessity of adopting special measures for protection of the floral zones ; several species that are rare and threatened with extinction should receive immediate attention for conservation before it is too late.

Many aspects of honey collection and behavioural pattern of honeybee hitherto unknown have been now known such as optimum size pattern, optimum distance of honeycomb from ground level and other phenological and ecological aspects of honey. This has brought out man-honey interactions in the marshy terrain of the Sundarbans, apart from other ecological traits of the Sundarbans. There is a definite host-plant preference for making honeycombs and *Excaecaria agallocha* (genwa) contributes about 39% of honeycombs. Ceriops *species* (Goran) contribute 11 per cent of honeycombs though they occupy approximately 90% of the forest areas. Distance range of 98% of host trees from ground level is 1.5 metres to 2.1 metres, but the optimum distance of honeycomb yielding maximum quantity of honey was found to be 2.5 metres.

A rational and scientific exploitation of fish species inhabiting the rivers, creeks and forest areas of Sundarbans estuary has immense economic potentiality. Several measures can be taken for maximisation of fish catch without affecting the natural resources of the region.

A study of various aspects of wildlife reserves brings out problems of conservation. These problems require management and it is possible to manage if the broad causes of extinction of

wildlife species are known. The population dynamics, ecological traits and animal-man interactions of the three major wild animals, viz., Rhinoceros, Indian Elephant and the Tiger, had been studied in depth. Several conservation strategies for improvement of man-animal relationship have emerged. These can be discussed and debated in wider forum. A lot of public education is needed as a first step. Project Tiger is not a project for artificial breeding of tigers—it is an attempt at conservation of nature, and is designed to conserve the entire ecological fabric in natural ecosystem of which dangerously beautiful tiger is the supreme predator.

A study of various causes of imbalance in nature brings out the predominant role of man in nature. He is always interacting with other living organisms for benefit of his own race ; but such interaction becomes counterproductive for human existence. Man thinks that other living organisms exist for his benefit and he does not exist for the benefit of other organisms.

There may be strong logic behind certain traditional practices such as worship of plants and trees. That may be the only way to protect them. Some plants are still worshipped by certain Communities Treatment of some diseases considered incurable is still found in plants and herb. These are still used with a good deal of success. Why should not such treatment be promoted, practised and widely encouraged ? In spite of the pressure for accepting modern and scientific approach, what were branded as orthodox and conservative ideas of the rural people are now imperceptibly gaining ground and appearing to be more logical. Only the future can tell whether the transformation of the rural society is for the good or bad of the mankind. The herbal treatment and tree worship persists and will perhaps continue to do so, despite modern education, scientific development and economic progress and the resultant social mobility.

The three villages in three different agro-climatic zones of West Bengal show at the micro-level what is happening at the macro-level. The extent of mutual dependence of man on plant and animal for the last three generations has been studied. The percentage of dependence on forests among the caste Hindus as secondary profession is on the increase in the present generation, but remains practically static as a primary profession. The percentage of dependence on forests among the scheduled

castes is insignificantly low for the last three generations, while among the scheduled tribes, it is on the decline in the present generation, compared to previous two generations. The village of lateritic zone of Southern Bengal indicates that the index of dependency on forestry activities has shown a sharp rise in the present generation, irrespective of caste. There may not be a method in all these changes, but there certainly exists a dynamic relationship which can be promoted or adversely affected by human behaviour. Many bioecological properties hitherto unknown could be uncovered as a result of this intensive study. Sundarbans swamps, though very dense in vegetal cover, record one of the lowest diversities, generic and specific. Generic diversity to maintain a positive correlation with specific diversity in a particular ecosystem. Foothill forests are very rich in tree flora which corresponds with highest concentration of arbereal avifauna, animals and terrestrial fauna. Generic and specific diversity were highest amongst the ground vegetation in the temperate ecosystem.

The middle hill zone, i. e., from 1001 metres to 1950 metres show maximum diversity in the ground vegetation. Taking the hill forests as a whole, the zone of vegetation from plains up to 1950 metres is the most viable. As such, foothill tree vegetation and lower and middle hill ground vegetation of the upper hills form the most important biologically viable zone. This was evidenced from the significantly high value of generic and specific diversity of the vegetation of this region. A low specific diversity gives a warning signal about the existence of a species which may be any one or combination of factors, like biotic interferences, environmental pollution, lack of regeneration, reproductive capacity, over exploitation and other abiotic or biotic variants of factors.

The study is of great significance as it helps to provide an approach to look upon the plant and animal as an essential part of biology. Why and how these require to conserved and which require special conservation measures have been identified. If timely measures are taken to ensure the survival of floral or faunal component in the region, it may be possible to bring about an integrated development of man, plant and animals. There can be no development of man with complete disregard to development of environment.

APPENDIX

TIGER LORE FROM SUNDARBANS

Sundarbans is the silent spectator of a ceaseless struggle for existence between predator and prey organisms, some win but some sustain defeat. I heard pathetic cries of innumerable tiger victims but in deadly calm Sundarbans it seems as if nothing has actually occurred. This is the peculiarity of this refuge which affords protection both to man and its man-eater.

SUNDARBANS : A PLACE OF TIGERS ON LAND AND CROCODILES IN WATER

Swaraj Ganguly lowered his hookah and gave a lop-sided smile. A timber contractor by profession, he was narrating how a reign of terror had engulfed Khatuajhuri. One after another timber workers fell prey to willy man-eaters. All precautionary measures proved ineffective.

Forest Department Staff were stationed with rifles. Yet, the animal took its ninth victim. Ganguly was shocked. Only three bodies could be recovered. The last victim was being carried back by a party of camp-mates. A giant tiger appeared ahead of the party, its black stripes on the body were shining in the slanting ray of the setting sun. The time was about 5 p.m. The dead body was hastily dropped. The entire party ran for life and dived into the river, not realising that it was still more dangerous owing to unseen whirlpools and multi-directional currents, not to speak of sharks and crocodiles. It was all over in a matter of seconds.

With a far-away look in his eyes, Ganguly described the horrifying scene. The frightened swimmers helplessly floating downstream and the man-eater leisurely following them along the bank of the river within easy sight. Death was inevitable, either in drowning by exhaustion or being caught alive by crocodiles, sharks or the tiger. But it had been decreed otherwise. The crew of 'Sundarbans Despatch Service' vessel bound for the erstwhile East Pakistan sighted the tragic scene. With the help of a speed boat, they rescued the unfortunate persons and took them to the camp. From a distance the tiger watched the rescue operations closely accepting his defeat but only temporarily.

Forest Department authorities ordered a temporary suspension of all work. But necessity knew no law. At the request of the permit holders the work was allowed to be resumed. Although security arrangements were tightened considerably, two more helpless workers were carried away by tigers in quick succession. Finally, with the sacrifice of eleven persons at the altar of the Dakshin Ray, the Forest Department officially closed the camp that had claimed so many lives. Swaraj Ganguly fell silent, his hookah forgotten.

The man-eater catches his prey on the right

Nurul Gazi had passed his 65th year in a happy home. His source of income was collecting Golpatta (*Nipa fruticans*) for roofing and he was one of the oldest permitholders with a vast knowledge of the terrain and its denizens. Caution was his second nature and on this particular day he had posted two men to watch and warn, while he himself concentrated on his work in Chamta-6. Lunch was over. About 3-30 p.m. Gazi noticed the absence of one watcher. Approaching the spot where the man was posted, discovered the man-eater's pugmarks on the receptive soil. A man of determination, Gazi followed the track with the other watcher till he sighted the man's dead body. Keeping his distance, he began scanning the area. The next moment the man-eater seemed to float silently though the air from behind and had the right side of the neck of Ashraf, the 40-year old second watcher, in his jaws. Though Gazi was able to scare away the animal, his only reward was that he was able to carry, along with others, both the dead bodies back to the waiting boat.

Seven sad days had passed and Gazi was forced to shed his sorrow and to start his work once again as money was running low. He landed in Gosaba-3 with four companions and was horrified to be confronted with fresh pugmarks of the dreaded tiger. To add to their miseries, a discussion on the plans for work and watch was interrupted rudely by the tiger's roar close at hand and all four of Gazi's companions were frightened into unconsciousness. This time luck was with him as he finally succeeded in scaring away the animal before it could launch an attack.

Sundarban tigers are like crafty smugglers

As with smugglers tigers in the Sundarbans, too avoid Government boats and patrolling forest staff.

A Forester happened to step outside the cabin of a boat around 11 p.m. one night. As he settled down on his bed after re-entering the cabin a soft thud was barely heard from the stern that jolted the boat slightly. All the inmates of the boat were cautioned. To ascertain the cause, a guard moved out with a torch. He scanned the front end of the boat and then turned the light towards the stern where he faced a tiger in a corner, ready to jump on him. The guard although scared had enough presence of mind to jump into the cabin and wake up the inmates. The disappointed tiger had to jump back into water and swim ashore as his manoeuvre failed.

The tiger steals a man from a boat

Sanyasi Mandal said : 'I opened my eyes after deep slumber. It was about 11 p.m. A pair of eyes was glowing in the poor, flickering light of the kerosene lamp in the boat and a warm putrid breath was fanning my face. The animal stood among four of us while choosing its prey. I tried to shout but my voice failed. I have seen many tigers but nothing like the one I saw this time.'

Sanyasi was in the fish trade for a long time and knew the terrain very well. A bright young man of 25, with thick tufts of curly hair and a complexion like varnished ebony, he often went in parties of five or six for fishing in the creeks and streams meandering through over-handing Goran and Garjan bushes. Each fisherman could hardly earn anything more than a meagre sum of Rs 2 to 3 a day while the middle man raked the lion's share of the profit. A lovable young man, Sanyasi kept close contact with the patrolling staff of the Forest Department. He was aware of the multi-directional currents of the channel running East-West and other hazards of the terrain.

It was customary for the fishing folk to get under the bamboo canopy of the boat after the day's work. On this day too, they had sat there and chatted for hours before turning in. Sanyasi cannot recall why he suddenly woke up to find the man-eater towering above him and his team-mates right under the canopy.

The animal selected Ananta Mandal, a man of 40 years, lifted him up his jaws and jumping out of the boat, vanished in the darkness. Nothing could be done as it all seemed to be over in a second.

Sanyasi recollected his promise to Ananta's wife that they would return together. He was disturbed over the thought of having to face the deceased's wife. Tigers, crocodiles, sharks and venomous snakes had to be encountered daily by them in a bostile terrain. Boats sink in storms, dacoits rob them of their belonging, drinking water and edibles ; yet they continue their work, ignoring the sorrowful tears of wives, mothers and children.

The cowardly man-eaters of sundarbans

Bishnu Mandal, aged 60 was a honey collector. He and his guru (preceptor), both priests, were in a group. The guru had a premonition of grave danger and decided that the men should stay together for some time. His hunch paid off and they sighted a huge tiger as they were detailing their duties. It was a Friday and they spent the rest of the day in prayer.

Early on Saturday morning they stepped out on the dry bank of a creek. Blessings were invoked from the Tiger-god. Mantras (incantations) were chanted to keep the man-eaters away and also to immobilise them. In the process, Mandal lagged behind the rest of the party. A huge tiger appeared as if from nowhere. But Mandal's courage prevailed and he faced the animal and shouted at it.

'You rascal—where do you come from ?' Mandal had a sharp cutting implement with him. But the tiger was hungry—snarling, twitching its tail with its facial muscles expanded, spitting frequently and the saliva oozing out, hind legs grazing the ground ; it visibly grew to double its size. Though death was imminent, Mandal did not give into panic but held the sharp instrument high ready to strike. This caused the animal to pause. Mandal's eyes looked with those of the tiger while he was backing slowly. He touched the ground with both hands and chanted a mantra. The animal scented danger and suddenly retreated. Mandal was rescued and found to be running high temperature. His eyes turned 'blood red' and have always

remained so thereafter. A few minutes' strain had changed his facial expression altogether.

Incantations drive away tigers !

Golam Muhammed of Gosaba, had been collecting honey for 20 years. As an eye-witness, he described how, under pathetic circumstances, he had lost his seven colleagues on different occasions.

But the present incident was different. It was a bright and clear morning. A mild breeze broke the gentle swell of the river into dancing little waves. Reclining at ease on the prow of the boat Golam Muhammed was watching the golden brown colour of golpatta and the emerald green of the Dhani grass (*Oryza coarctata*). The tide was running and the boat stood close to the bank. Golam, along with some others, was relaxing as he expected some of his men to join him. His son, cooking inside the boat, suddenly shouted 'Tiger—Tiger' and the animal was over Golam. With the impact of the jump the boat moved and instead of bringing Golam's neck between the canines the animal could only put the front paws on his knee. Golam, out of sheer fright and nervousness, caught hold of the man-eater's broad head and shouted in a freezy : 'You rascal, get away ; don't you know where from you have come ?' Almost simultaneously his other colleagues arrived ; repeated shouting and beating with the sticks made the tiger retreat into the forest. Golam showed his scar which was still giving him trouble. He, however, proudly asserted that the man-eater had to depart as he had chanted mantras.

The tigers know the ways of men

A party of honey collectors had just returned to the boat with the lengthening of shadows when a swarm of low flying bees attracted Ananta Mandal's attention. He thought a few honeycombs must be located close and set out for the combs with two other honey collectors.

To ascertain the exact location Ananta climbed a tree. A comb was located and two of them proceeded towards it.

The area was bushy and almost impenetrable. As he climbed

down, Ananta saw a tiger crouching stealthily towards a companion of his from a very close distance. Fright paralysed him and he could neither shout nor move. He saw the animal twitching its tail and just about to leap on its prey. The unfortunate man hardly knew that his death warrant had been signed.

As the animal swiftly leaped high in the air, the victim had some premonition of danger and turned twice so that the tiger missed the target by inches—a bush having intercepted. The scene that followed for the next few seconds was unique for the Sundarbans. The tiger was trying to get a grip with his jaws while the three honey collectors were loudly beating the ground with branches and shouting lustily. This was perhaps a danger signal for the tiger and it vanished hurriedly.

To eke out a living, they have to trek such risky and difficult, mud deep terrain where venomous snakes, deadly crocodiles and man-eaters are encountered frequently.

The incantations could not save the priest

Maherali Mallick, 60, had the terrifying experience of a life- and death struggle of the permit holders for survival. He had seen two of his men being taken away by man-eaters.

While seven of his men were working, two were employed to guard. It was about 9 a.m. The work started at 8 a.m. when it was noticed that one of the watchers was missing. A search revealed the fresh pugmarks of a tiger and a few fresh drops of blood.

A search party was arranged with a 'Priest' leading it. They had trekked about 5 kilometers tracking the blood drops and the body was found in a Hental (*Phoenix*) bush. On the 'Priest' lay the responsibility of recovering the dead body. On careful search it was found that the tiger was not in the vicinity.

As the priest went close to the dead body, the man-eater roared savegely and pounded on him from the right and, in full view of the other men, carried him away as if to mock at mantras.

It was a pitiable story of death of two hapless men.

The tigers are like crafty thieves

Another honey collector, Nagar Ali of Katakhali, considers the tiger a coward. He said they act like thieves, coming stealthily and attacking from behind.

Once he and his team-mates were on a boat anchored in Chamta river. It was dark ; food was being cooked and everyone was relaxing, some were singing and some were engaged in conversation. Malek Molla was seated in a corner and was not participating in any discussion.

All became alert as a sound was heard of something heavy splashing in the water. Where was Molla ? It certainly seemed that he had vanished. Torches were flashed all round and the faint figure of the man-eater with 'Molla' clamped between its canines, was spotted on the far bank.

Molla's half-eaten body could be recovered only the following day. The Sundarban man-eater eats the soft stomach first when breaking its fast.

Nagar Ali also recalls that another worker was killed in the same compartment the previous year under similar circumstances.

The tiger phobia

Basanta Raftan, 40, of Hinglegunj had come face to face with two charging tigers. He survived both the charges but went down for several months thereafter with a high fever.

On the second occasion, six of his colleagues were engaged in cutting leaves. One was posted to guard against any probable attack from crocodiles or tigers. Yet stealing through the shadows a tiger came slinking in and took away Bimal Raftan, 40, from one corner and the others never knew about it for a full ten minutes. The fact was verified from the pugmarks and blood drops.

Determined to recover the dead body, they followed the blood trail and the spoors. After trekking for about half a kilometre inside the forests, they found the tiger eating the dead. The animal displayed unmistakable signs of dissatisfaction and anger as it snarled and growled. Sibu Mandal, one of the men, dropped down unconscious in sheer fright. Once he regained consciousness, he started shouting 'Tiger'—'Tiger'—'Tiger'. Sibu could only be carried to the boat after the tiger had moved

away from the kill. He ran high temperature for months with regular fits of nervousness and he kept shouting 'Tiger'—'Tiger' —'Tiger' in his delirium.

Unique is the behaviour pattern of the man-eater

Dhirendra Mandal described how some tigers cross over to the villages in search of cattle and dogs ; and was emphatic that man-eaters *do not enter any village.* In this respect the man-eaters of Sundarban differ from the man-eaters elsewhere in India. It is through causing annoyance or irritation that people sometimes get mauled or killed by tigers.

Mandal relates an incident. A big crowd had assembled as news reached Lahiripal village that a gunin (priest) had mesmerized a tiger in a plantation of tall grass. A few shikaris also came with their firearms but could not do anything as they could not take up any convenient position for shooting. An artificial camouflage was erected and the shikaris positioned themselves inside. The priest permitted them to shoot the tiger on condition that substantial offering would be made to the Tiger-god of the Sundarbans.

The Shikaris shot at the tiger, but the tiger reacted by jumping at them although it missed its target. The wounded tiger finally hid inside a small bush across a channel. Once again the shikaris chased it and the tiger returned to the plantation.

The priest wanted to mesmerize it once again but locals disapproved of his doing so as the tiger was wounded.

The priest, however, said that he would make it easy for the shikaris to shoot by removing the tall grass. His efforts only made the tiger jump on him. He was caught by the neck and died on the spot. Subsequently, the wounded tiger was shot and killed.

Tiger's saliva blinds the human victim

Rashik Mandal, 40, of Nezat is engaged in fishing avocations at Sundarbans for the last 20 years. One evening in a side creek of Charamayadwip Mandal was engaged in 'Kum' fishing (putting obstructions to the mouth of the creek where fishing is intended) along with his other companions. It was ebbtide

and the water was gushing out a great speed. On the edge of the creek Rashik suddenly finds a cheetal grazing keora leaves and was casting careful looks to monitor the whole proceedings. Rashik had the least idea that he was also being closely monitored by a full grown tiger from the other side of creek. Within practically no time Rashik and his companions heard the death-cry of cheetal and a viscous substance on his right eye. The companions along with Rashik fell unconscious. On regaining senses, the companions could find that the tiger has jumped across the narrow creek with his mouth wide open and as a result the saliva of the animal trickles down. Rashik has suddenly discovered that he could see nothing from his right eye and was blinded in the affected eye. This incident has aroused curiosity amongst the naturalists to probe into the riddle.

Man in the jaws of tiger is like a fish in the mouth of a cat

Nibaran Mandal, 45, of Chotomollakhali was a professional honey collector and had seen his friends being taken away by man-eaters in various situations. One such fantastic incident he has narrated.

It occurred near the banks of Havila-Duania river on a bright sunny morning. Ten honey collectors clambered down to the bank, stood in a line facing the morning sun and the *baubi* commenced chanting mantras. The surface of the meandering river was crystal clear and calm and smooth as a sheet of glass. The mantras were chanted and the Tiger-god was being invoked.

Suddenly a mild thud broke the silence and Deben Mandal standing in the middle, was seen in the jaws of a man-eater ; the sight was akin to a fish in a cat's mouth and he was being taken towards the jungle. Nibaran was next to Deban but due to shock he did not realise what had happened. Four of the collectors however fell down unconscious at the sight. Nibaran quickly arranged a search-party and followed the pugmarks and the trail of fresh blood. They recovered the half-eaten body of Deben after taking grave risks. The stomach was found to be completely consumed.

None could solve the mystery of the man-eater's sudden appearance eluding so many watchful eyes.

A strange fact, confirmed by many witnesses, is that the human body, without life, contracts to about half its size enabling the man-eater to carry it away with ease.

Sundarbans is really an ideal laboratory of nature. It provides astonishing examples as to how a physical and chemical environment can exert influence to the different forms of life. The extent of endogenous and exogenous periodism, osmo regulatory adaptations amongst different organisms were perhaps nowhere so much pronounced and diversified as in Sundarbans. Man-eating tigers—astonishingly cunning and ferocious, world's largest crocodiles, water and land lizards, crab eating spotted dear, monkeys and wild pigs, innumerable varieties of crabs, other wildlife and more than two hundred species of fish open new vistas of research and investigation into hitherto unknown biological properties of the region.

BIBLIOGRAPHY

Andrewartha, H. G. and Birch, L. C., The distribution and Abundance of Animals, vol. I-XVIII, University of Chichago Press, Chichago, 1954.

Bagchi, Deepika, A study in Urban Tribal Relationship, Deccan Geography, vol. VIII, Nos. 1 & 2, 1960.

Ben, Osborn, How Rainfall and Rub-off Erode Soil, Water, Yearbook of Agriculture, The United States Department of Agriculture, 1955.

Bor, N. L., The Relicit vegetation of the Shillong Plateau, vol. III, No. 6, Indian Forest Records News Series, Botany, Assam, 1942.

Bhattacharjee, T. K., Valmiki Ramayana, translated from Original Sanskrit, Calcutta, 1960.

Bose, Nirmal Kumar, Some Indian Tribes, National Book Trust, New Delhi, 1972.

Bhowmick, P. K., Occultism in Fringe Bengal, Calcutta, 1978.

Carson, Rachel, Silent Spring, Houghton Miffin Co., Boston, 1962.

Chakrabarti, Kalyan and Chaudhuri, A. B., Wildlife Biology of Sundarbans Forests—Observations on Tigers, Cheetal, vol. 15, No. 11-30, Dehra Dun, 1972.

——— Wildlife Biology of the Sundarbans Forests—A study of the habit and habitat of the Tigers, Bulletin of the Botanical Society of Bengal, 26 (I), 63-66, Calcutta, 1973.

——— Wildlife Biology of the Sundarbans Forests—Biological study of Fish and Fish Resources and Biological basis of Rational Fishery, Science and Culture, vol. 40, 93-99, Calcutta, 1974.

——— Human casualties from man-eating Tigers can be Reduced, Science and Culture, vol. 40, 207-210, Calcutta, 1974.

——— Generic and Specific diversity of Eastern Himalayan Forests, Bulletin of Botanical Society of Bengal, vol. 30, 101-106, Calcutta, 1976.

Chakrabarty Kalyan, A Statistical Approach to Wild Animal Population Analysis, Cheetal, vol. 19, No. 1, 19-29, Dehra Dun, 1977.

——— Ecology of the Sundarbans Tiger with a particular reference to range of habitat and adaptibility to changes, Cheetal, vol. 20, Nos. 2 & 3, 3-15, Dehra Dun, 1979.

Chakrabarti, Kalyan, Legends of Sundarbans, The Statesman, Calcutta, August, 1983.

——— Dynamics of flora-fauna diversity in the Mangroves of Sundarbans in Comparison to laterite forests of South Bengal and North Bengal Forests—A Bioecological study, The Indian Journal of Forestry, vol. 7, No. 3, 220-232, Dehra Dun, 1984.

——— Tiger in the Mangrove Forests of Sundarbans—an ecological study, Tiger Paper, vol. XIII, No. 2, 8-11, Bangkok, 1986.

——— Honey—cause of human misery, The News Time, Hyderabad, 1986.

——— Sundarbans Tiger—why are they man-eater ? Science Reporter, vol. 22, No. 4, 239-240 & 256, New Delhi, 1985.

——— The Sundarbans Forests—where life began, Sanctuary Asia, vol. V, No. 4, 324-355 & 359, Bombay, 1985.

——— An Ecobiological study on Conservation Mangrove Ecosystem of the Sundarbans, Van Vigyan, vol. 23, Nos. 3 & 4, 53-60, Dehra Dun, 1985.

——— Forests and Forests' People, Amritabazar Patrika, Calcutta, April 3, 1988.

——— Man in the Forest, The Statesman, Calcutta, June 30, 1990.

Elton, C. S., The Ecology of Invasions by Animals and Plants, Methuen & Co., London, 1958.

Frazer, J. G., The Golden Bough, Macmillan, ab. edn. 1951.

Glenn, L. Jepson, Riddles of the Terrible Lizards, American Scientist, New York, 1964.

Kendiegh, S. C., Ecology with special reference to Animals and Man, Prentice-Hall of India Pvt. Ltd., New Delhi, 1980.

Lindblom, C. E., Decision making in Taxation and Expenditures in Public Financer, Needs, Sources and Utilisation, National Bureau of Economic Research, New York, 1961.

Law Bimala Churn, Ujjayini in Ancient India, Published by the Gwalior Govt., Gwalior, 1944.

Leyden, John, Memories of Zahir-Ed-Din Mohammad Babar, Oxford, 1921.

Maringes, J., Gods of Prehistoric Man, Weidenfeld Nicholson, London, 1960.

Mookherji, Radhakumud, A History of Indian Shipping and Maritime Activity from the Earliest Times, Calcutta, 1912.

Majumder, D. N., Races and Cultures of India, Asia, Allahabad, (also see Realm and Region in Traditional India ed. Richard G. Fox), New Delhi, 1958.

Pal, B. P., Environmental Conservation and Development, Indian Environmental Society, Nataraj Publishers, Dehra Dun, 1982.

Philp-ot, J. H., The Sacred Trees, Oxford, 1897.

Puri, G. S., Indian Forest Ecology, vol. I, Calcutta, 1960.

Parashnis, S. S., Forestry in the Rural Economy of India with Particular Reference to Agriculture—A Dissertation for the Award of Degree of Doctor of Philosophy submitted under the University of Michigan, 1976.

Ray Choudhury, H. C., Political History of Ancient India, Calcutta, 1927.

Rhys Davids, W. W. & Bushell, S. W., On Yuanchwang's Travels in India, vol. I & II, London, 1904-05.

Rao, V. S., Forest Ecology—A Popular Lecture note delivered at Forest Research Institute, Dehra Dun, 1967.

Randhawa, N. S., Beautiful Trees and Gardens, National Book Trust, New Delhi, 1961.

Shah, N. C., The Role of Ethnobotany in Relation to Medicinal Plants in India, Paper Read at the First Botanical Conference, Meerut, 1978.

Sahni, B., Recent Advances in Indian Palaeobotany : Proceedings of the Twenty-fifth Indian Science Congress, Calcutta, 1938.

Singha, K. P., Mahabharata in Bengali Translated from original Sanskrit version, Calcutta, 1883.

Stebbing, E. P., The Forests of India, vol. I, London, 1921.

Stracey, P. D., Wildlife in India—Its conservation and control, Department of Agriculture, New Delhi, 1963.

Sengupta, Sankar, Folklore of Bengal—A projected study, Indian Publications, Calcutta, 1976.

——— Sacred Trees Across Culture and Nations, Indian Publications, Calcutta, 1980.

Sur, A. K., Folk Elements in Bengali Life, Calcutta, 1975.
Santapu Rev. H., History of Botanical Researches in India, Burma and Ceylon, Bangalore, 1958.
Vidyarathi, L. P., Cultural Types in Tribal Bihar, Journal of Social Research, Ranchi, 1958.
Vincent A. Smith ; Akbar, The Great Mogul, Delhi, 1962.
William Foster, Early Travels in India (1583-1619), Cambridge, 1921.

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Plants and animals are complements
to each other, in a web of life,
and they interact with each other
in a finely balanced fulcrum.
Destruction of one part of the
ecosystem sets in a chain reaction
to the complex harmony in
nature affecting ultimately the
MAN.

In this book a triangular relationship
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have been established and bridged
a long-felt vital gap in the
information flow in an ecological
setting. The unique feature in this
book is the narrative description
of the evolution of Indian Forests
and its diversity through the ages
and its general impact on social
ECOLOGY.